INTERNATIONAL STANDARD

ISO 24202

First edition
2023-10

Oil and gas industries including lower carbon energy — Bulk material for offshore projects — Monorail beam and padeye

Industries du pétrole et du gaz, y compris les énergies à faible teneur en carbone — Petits matériels pour projets Offshore — Poutres et oeilletons des monorails

Reference number
ISO 24202:2023(E)

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Published in Switzerland

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Foreword

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This document was prepared by Technical Committee ISO/TC 67, *Oil and gas industries including lower carbon energy*, in collaboration with Technical Committee ISO/TC 8, *Ships and marine technology*, SC 8, *Ship design*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document aims to reduce the number and variations in requirements to the minimum necessary to reflect a common and global best practice based upon existing standards and regulations.

The main benefit of standard shapes and dimensions for monorail beams and padeyes is to gain a reduced delivery time, more streamlined and efficient engineering and construction as well as improved cross use of standardized monorail beams and padeyes between projects. The specified test methods are provided to verify by proof load test that the monorail beams and padeyes including foundation structures have the required load carrying capacity. The detailed test methods provided in this document aim to reduce overall testing time by early stage test and inspection, and to provide a consistent and proven approach to ensure structural strength of monorail beams and padeyes.

Oil and gas industries including lower carbon energy — Bulk material for offshore projects — Monorail beam and padeye

1 Scope

The purpose of this document is to provide a uniform standard for monorail beams and padeyes when these structures are designed and constructed in offshore projects.

This document specifies the design and material requirements for mechanical handling including monorail beams and padeyes during operations of offshore facilities. This document specifies the standard shapes and dimensions of monorail beams and padeyes and provides material requirements for these bulk materials.

This document is applicable to the structures of monorail beams and padeyes for topside systems for fixed or floating offshore projects.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2566-1, *Steel — Conversion of elongation values — Part 1: Carbon and low-alloy steels*

ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

ISO 7452, *Hot-rolled steel plates — Tolerances on dimensions and shape*

ISO 7500-1, *Metallic materials — Calibration and verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Calibration and verification of the force-measuring system*

ISO 10474, *Steel and steel products — Inspection documents*

ISO 19902, *Petroleum and natural gas industries — Fixed steel offshore structures*

ANSI/AISC 360-10, *Specification for Structural Steel Buildings*

ASTM A370, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

EN 10163-2, *Delivery requirements for surface condition of hot-rolled steel plates, wide flats and sections — Part 2: Plate and wide flats*

EN 10163-3, *Delivery requirements for surface condition of hot-rolled steel plates, wide flats and sections — Part 3: Sections*

EN 10204, *Metallic products — Types of inspection documents*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1 Terms and definitions

3.1.1
monorail beam
beam designed to support trolley hoists or other devices rolling directly on its bottom flange

3.1.2
padeye
lift point consisting essentially of a plate, reinforced by cheek plates if necessary, with a hole through which a shackle can be connected

Note 1 to entry: Padeye only covers material handling as repair and maintenance activity during operation and not construction activities, such as module lifting and block lifting.

[SOURCE: ISO 19901-6:2009, 3.63, modified — Note 1 to entry has been added.]

3.1.3
proof load test
production load test performed to validate the structural strength of *monorail beams* (3.1.1) and *padeyes* (3.1.2) including supporting structures

3.1.4
sampling test
conservative selection of *monorail beam* (3.1.1) or *padeye* (3.1.2) to ensure structural strength check considering variable design parameters, such as safety working load, size, shape and span

Note 1 to entry: To reduce actual load test, design verification is required to verify structural strength of monorail beams and padeyes.

3.2 Abbreviated terms

ASD	allowable stress design
CJP	complete joint penetration
DF	design factor
DAF	dynamic amplification factor
DLF	design load factor
LRFD	load and resistance factor design
MPI (MT)	magnetic particle inspection (magnetic particle test)
NDT (NDE)	non-destructive test (non-destructive examination)
PJP	partial joint penetration
PVC	polyvinyl chloride
SWL	safety working load
UT	ultrasonic test
VT	visual test
WPG	welded plate girder

4 Requirements and specifications for monorail beams

4.1 General

This clause specifies requirements for design and test of monorail beams made from rolled or built-up section as per material data sheets in Annex A. This specification applies to monorail beams and their components only; it does neither apply to supporting structures, to travelling trolleys and lifting appliances operating on the beams nor to crane gantries or rails.

Monorail beams should be designed to sufficiently support the loads from lifting equipment considering SWL and arrangement of supporting structures. The design shall be based on the loads and load effects, which are described by the manufacturer of the specific lifting equipment or described in 4.2, that are to be suspended by the monorail beams.

4.2 Design loads

Unless otherwise agreed or stated by the manufacturer of the lifting equipment, the following design loads apply:

a) The safety working load (SWL) for monorail beams shall be designed equal to or larger than the selected trolley hoist SWL.

b) Design load factor (DLF) shall be taken as per Table 1.

c) The information on trolley hoist self-weight provided by manufacturer shall be used for design.

d) The horizontal load shall be taken as minimum 10 % of the design load in longitudinal direction and 20 % of the design load in transverse direction acting in the lowest suspension point including DLF. Horizontal loads in both directions shall be applied simultaneously to the vertical design load.

Table 1 — Design load factor depending on SWL

SWL	DLF for LRFD	DLF for ASD
SWL ≤ 5 t	2,52	1,74
SWL > 5 t	2,18	1,51

NOTE 1 DLF for LRFD is based on DAF and DF.

NOTE 2 DLF for ASD is converted from DLF for LRFD considering safety factor (0,6) and material resistance factor (1,15).

NOTE 3 In the proposed DLF, the value of the dynamic amplification factor (DAF) has been taken as 1,5 for SWL up to and including 5 t, and 1,3 for SWL above 5 t.

NOTE 4 Design factor (DF) is defined as partial load factor multiplied with consequence factor. For design of monorail beams, DF 1,68 is considered as single critical elements.

4.3 Deflection

Vertical deformation, δ_{ver}, of a monorail beam shall be calculated under the SWL with trolley hoist self-weight as single load at middle of simple support or at end of cantilever (excluding load factors and self-weight of monorail beam). δ_{ver} shall conform to the following allowable values:

a) for simple support member with both side boundary as shown in Figure 1: $\delta_{ver} \leq L / 500$

b) for cantilever member: $\delta_{ver} \leq L / 250$

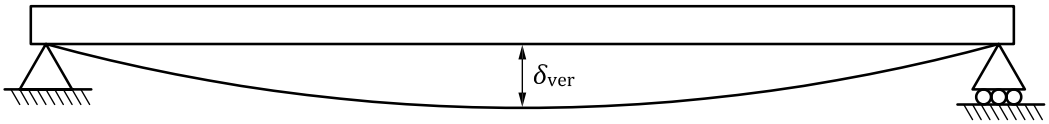


Figure 1 — Vertical deformation

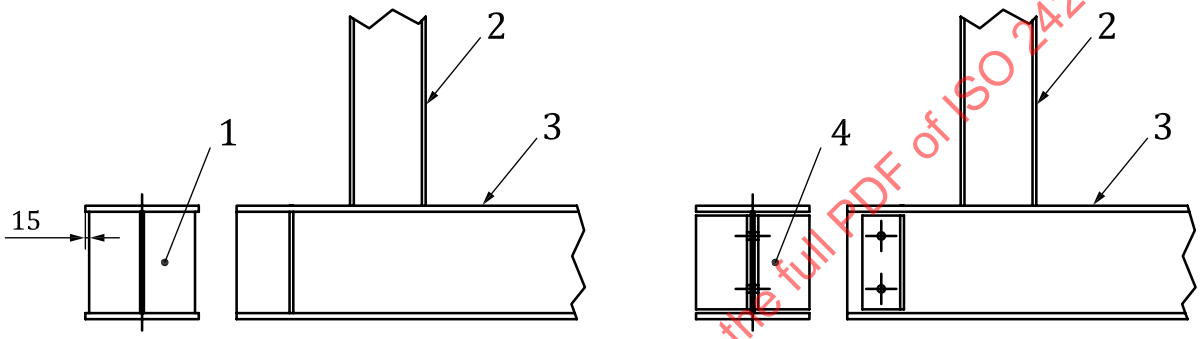
Any deformation requirement by manufacturer shall be additionally considered.

4.4 End stoppers

Monorail beam shall be provided with end stoppers on all open ends where the lifting equipment can become detached from the monorail beam. Either welded closed end or bolted type for maintenance shall be considered as end stoppers. The contact area of the end stoppers shall align with the part of the lifting equipment which is designed for such contact.

End stopper width shall be extended to the edge of the load bearing flange to prevent trolleys of any dimension, under any operating condition, from inadvertently passing the end stopper. For welded closed end stopper, end stopper width can be located at typically 15 mm from edge of flange as shown in Figure 2 a). The end stopper is generally installed as bolted type for easy installation and removal of trolley as shown in Figure 2 b).

Dimensions in millimetres



a) Closed type end stopper by welding **b) Bolted type end stopper**

Key

1 welded type end stopper
2 supporting structure
3 monorail beam
4 bolted type end stopper

Figure 2 — Example of end stopper

4.5 Fabrication

The detailed specification of dimensions and tolerances for monorail beams shall be as specified in Annex A.

Welded joints on the rolling surface of monorail beam shall be ground flush.

4.6 Painting and marking

Monorail beams shall be permanently marked with unique identification with any limiting conditions and SWL visible from floor level with font letters to be minimum 100 mm high. Monorail beams may be painted yellow, yellow with black stripe, white or any other colour which is noticeably different than the structural steel.

4.7 Material grade and design temperature

The design class of monorail beams shall be considered as DC4, in accordance with the design class approach of ISO 19902. The structural significance of monorail beams including supporting structures are not major structures for the global integrity of topside structures and the consequences of its

failure are locally impacted on topside structures. That means the failure of monorail beams including supporting structures will not have substantial consequences. Considering the geometrical complexity, the monorail beams mainly have biaxial stress pattern, which are mainly axial beam bending stress with transverse stress on flange.

Design temperature for material selection is –20 °C. Design temperature lower than –20 °C is not covered in this document.

4.8 Strength assessment

The strength assessment for monorail beams shall be carried out in accordance with design requirements in ANSI/AISC 360-10 using the design loads as specified in 4.2.

4.9 Fatigue assessment

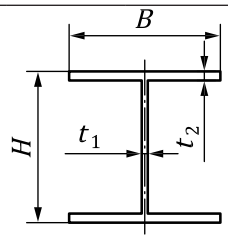
The monorail beam structure shall be verified for fatigue assessment under load combinations involving frequently applied loads and for the service life specified.

Fatigue assessment is not required for monorail beams, if the number of cycles is less than 20 000 and if the capacity load is infrequently used.

4.10 Specification of beam size and span

The specified beam size and span for each SWL as shown in Table 2 are based upon the design load specified in 4.2, the deflection requirements specified in 4.3 and the strength assessment specified in 4.8.

Table 2 — Specified beam size and span for each SWL

SWL	Type	Monorail size (mm)				Maximum span (m)		Maximum allowable "*k*"
						Simple 	Cantilever 	
		H	***B***	t_1	t_2			
≤ 1 t	H	200	200	8	12	6,0	1,50	2,00
	H	294	200	8	12	6,0	1,50	2,00
≤ 2 t	H	200	200	8	12	5,0	0,75	2,00
	H	294	200	8	12	5,0	1,50	2,00
	H	400	200	8	13	5,5	1,50	2,00
≤ 3 t	H	200	200	8	12	3,5	0,75	2,00
	H	294	200	8	12	4,0	1,25	2,00
	H	400	200	8	13	4,5	1,50	2,00
	H	390	300	10	16	6,0	1,50	2,00
≤ 4 t	H	200	200	8	12	2,5	0,75	1,88
	H	294	200	8	12	3,5	0,75	1,93
	H	300	300	10	15	6,0	1,5	2,00
	H	400	200	8	13	4,0	1,25	2,00
	H	390	300	10	16	6,0	1,50	2,00
≤ 5 t	H	294	200	8	12	3,0	0,75	1,60
	H	300	300	10	15	6,0	1,25	2,00
	H	400	200	8	13	3,5	1,00	1,93
	H	390	300	10	16	6,0	1,50	2,00

NOTE 1 It is also acceptable to apply welded plate girder (WPG) which has equivalent or above scantling against sectional property of beams summarized in this table. For example, if the designer uses same inertia, elastic modulus and flange thickness of the section reported in this table, it is possible to accept lower beam height.

NOTE 2 The specified sizes and spans in this table are fully conforming with the requirements of resistance of bottom flanges to wheel loads in EN 1993-6:2007 based on point loads with four wheels and distance from flange edge of 5 mm to 25 mm depending on SWL. Hoist class for EN code check is considered as "HC2" in accordance with yard practice and experience.

NOTE 3 Maximum allowable "k" is a factor for linear superimpose stresses effect on flange of monorail beam considering distance between wheels of trolley for the selection of trolley hoist or flange design of monorail beam. In accordance with flange check by EN 1993-6:2007, this table provides allowable maximum "k" factor. For maximum allowable "k" factor of 2,0, current monorail beam size in this table can be applied to any type of trolley. For maximum allowable "k" factor of 1,0, current monorail beam size in this table is not to be applied to any superimpose stresses and it is required to apply special trolley that is no superimpose stresses due to between wheels of trolley.

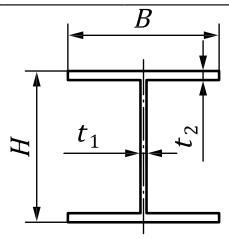
NOTE 4 For monorail beam with SWL above 25 t, the structural design using WPG can be performed separately.

NOTE 5 Trolley hoist self-weight for monorail design considered in the load specifications provided in this table is 15 % of SWL for up to and including 1 t and 10 % of SWL for above 1 t.

NOTE 6 Boundary conditions for the specified sizes of monorail beams are conservatively considered for maximum bending moment and shear force as simple support for both sides supporting beam and fixed end for cantilever beam.

NOTE 7 Boundary conditions for deflection check are considered for maximizing the deflection as hinged and pined boundary for simple support and fixed end for cantilever beam as shown in figures in this table.

Table 2 *(continued)*

SWL	Type	Monorail size (mm)				Maximum span (m)		Maximum allowable "k"
						Simple 	Cantilever 	
		H	*B*	t_1	t_2			
≤ 6 t	H	294	200	8	12	2,5	0,75	1,28
	H	300	300	10	15	5,5	1,25	1,90
	H	400	200	8	13	3,5	1,00	1,59
	H	390	300	10	16	6,0	1,50	2,00
≤ 7 t	H	294	200	8	12	2,5	0,50	1,08
	H	300	300	10	15	5,0	1,00	1,61
	H	400	200	8	13	3,0	0,75	1,35
	H	390	300	10	16	5,5	1,50	1,93
	H	488	300	11	18	6,0	1,50	2,00
≤ 8 t	H	300	300	10	15	4,5	1,00	1,39
	H	400	200	8	13	2,5	0,75	1,17
	H	390	300	10	16	5,0	1,50	1,67
	H	488	300	11	18	6,0	1,50	2,00
≤ 10 t	H	300	300	10	15	3,5	0,75	1,14
	H	390	300	10	16	4,5	1,25	1,35
	H	488	300	11	18	5,5	1,50	1,78
	H	588	300	12	20	6,0	1,50	2,00

NOTE 1 It is also acceptable to apply welded plate girder (WPG) which has equivalent or above scantling against sectional property of beams summarized in this table. For example, if the designer uses same inertia, elastic modulus and flange thickness of the section reported in this table, it is possible to accept lower beam height.

NOTE 2 The specified sizes and spans in this table are fully conforming with the requirements of resistance of bottom flanges to wheel loads in EN 1993-6:2007 based on point loads with four wheels and distance from flange edge of 5 mm to 25 mm depending on SWL. Hoist class for EN code check is considered as "HC2" in accordance with yard practice and experience.

NOTE 3 Maximum allowable "k" is a factor for linear superimpose stresses effect on flange of monorail beam considering distance between wheels of trolley for the selection of trolley hoist or flange design of monorail beam. In accordance with flange check by EN 1993-6:2007, this table provides allowable maximum "k" factor. For maximum allowable "k" factor of 2,0, current monorail beam size in this table can be applied to any type of trolley. For maximum allowable "k" factor of 1,0, current monorail beam size in this table is not to be applied to any superimpose stresses and it is required to apply special trolley that is no superimpose stresses due to between wheels of trolley.

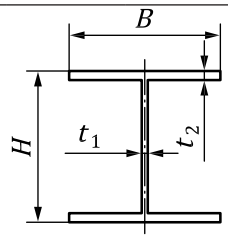
NOTE 4 For monorail beam with SWL above 25 t, the structural design using WPG can be performed separately.

NOTE 5 Trolley hoist self-weight for monorail design considered in the load specifications provided in this table is 15 % of SWL for up to and including 1 t and 10 % of SWL for above 1 t.

NOTE 6 Boundary conditions for the specified sizes of monorail beams are conservatively considered for maximum bending moment and shear force as simple support for both sides supporting beam and fixed end for cantilever beam.

NOTE 7 Boundary conditions for deflection check are considered for maximizing the deflection as hinged and pined boundary for simple support and fixed end for cantilever beam as shown in figures in this table.

Table 2 *(continued)*

SWL	Type	Monorail size (mm)				Maximum span (m)		Maximum allowable "*k*"
						Simple 	Cantilever 	
		H	***B***	t_1	t_2			
≤ 15 t	H	300	300	10	15	2,5	0,50	1,00
	H	390	300	10	16	3,0	0,75	1,00
	H	488	300	11	18	4,0	1,00	1,18
	H	588	300	12	20	4,5	1,25	1,51
	H	700	300	13	24	6,0	1,50	2,00
≤ 20 t	H	488	300	11	18	3,0	0,75	1,00
	H	588	300	12	20	3,5	1,00	1,12
	H	700	300	13	24	4,5	1,25	1,68
	H	800	300	14	26	5,5	1,50	2,00
≤ 25 t	H	488	300	11	18	2,5	0,50	1,00
	H	588	300	12	20	3,0	0,75	1,00
	H	700	300	13	24	4,0	1,00	1,31
	H	800	300	14	26	4,5	1,00	1,58

NOTE 1 It is also acceptable to apply welded plate girder (WPG) which has equivalent or above scantling against sectional property of beams summarized in this table. For example, if the designer uses same inertia, elastic modulus and flange thickness of the section reported in this table, it is possible to accept lower beam height.

NOTE 2 The specified sizes and spans in this table are fully conforming with the requirements of resistance of bottom flanges to wheel loads in EN 1993-6:2007 based on point loads with four wheels and distance from flange edge of 5 mm to 25 mm depending on SWL. Hoist class for EN code check is considered as "HC2" in accordance with yard practice and experience.

NOTE 3 Maximum allowable "k" is a factor for linear superimpose stresses effect on flange of monorail beam considering distance between wheels of trolley for the selection of trolley hoist or flange design of monorail beam. In accordance with flange check by EN 1993-6:2007, this table provides allowable maximum "k" factor. For maximum allowable "k" factor of 2,0, current monorail beam size in this table can be applied to any type of trolley. For maximum allowable "k" factor of 1,0, current monorail beam size in this table is not to be applied to any superimpose stresses and it is required to apply special trolley that is no superimpose stresses due to between wheels of trolley.

NOTE 4 For monorail beam with SWL above 25 t, the structural design using WPG can be performed separately.

NOTE 5 Trolley hoist self-weight for monorail design considered in the load specifications provided in this table is 15 % of SWL for up to and including 1 t and 10 % of SWL for above 1 t.

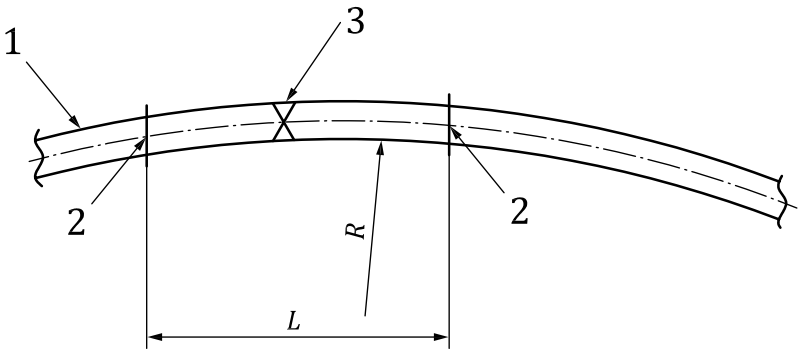
NOTE 6 Boundary conditions for the specified sizes of monorail beams are conservatively considered for maximum bending moment and shear force as simple support for both sides supporting beam and fixed end for cantilever beam.

NOTE 7 Boundary conditions for deflection check are considered for maximizing the deflection as hinged and pined boundary for simple support and fixed end for cantilever beam as shown in figures in this table.

4.11 Curved monorail beams

Where the horizontal radius (R) of the monorail beam is larger than twice the distance between the girder supports (L), the designer may neglect to include the effect of curvature and design the girder as if it was straight, provided that the monorail beam extends without joints at least one span on either side of the curved span. A curved monorail beam is shown in Figure 3.

In other cases, the curved monorail shall be analysed as a horizontally curved girder.



Key

1 continuous curved monorail beam
2 supporting structures
3 load
L span of monorail beam as distance between the girder supports
R horizontal radius of the monorail beam

Figure 3 — Curved monorail beam

4.12 Arrangement for installation of hoists and trolley

Considering installation and removal of hoists and trolleys on monorail beam, the installation arrangement can be applied. A typical example design of installation arrangement on monorail beams is shown in Figure 4.

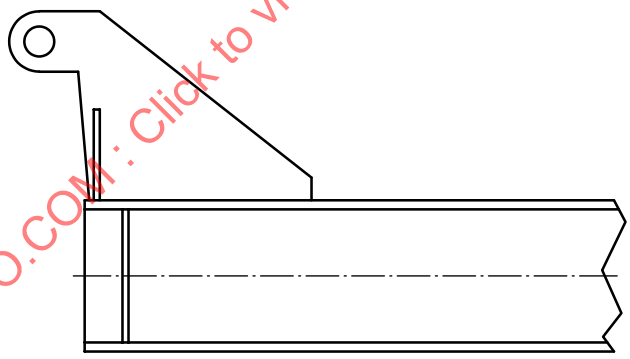
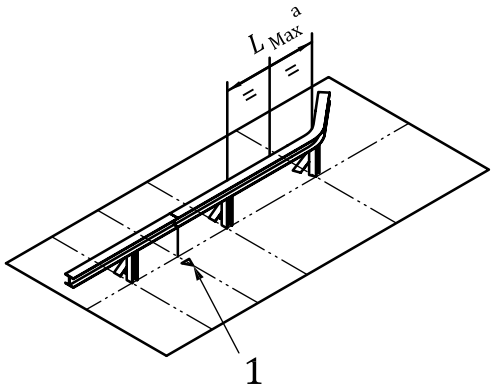


Figure 4 — Example of arrangement for installation of hoists and trolley

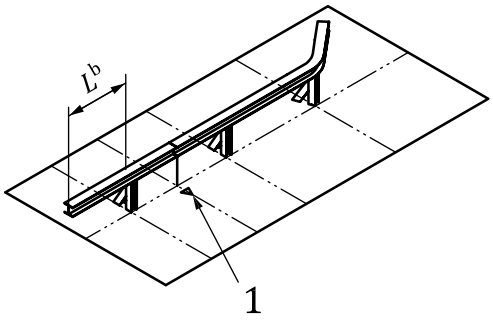
4.13 Load test requirements

Each monorail beam shall be subjected to a proof load test as 1,25 times of SWL.

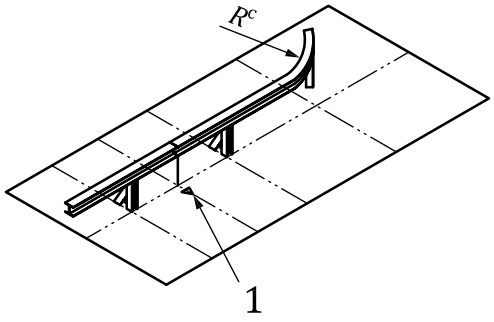
The test load shall be applied in the positions of the monorail beam as shown in Figure 5.



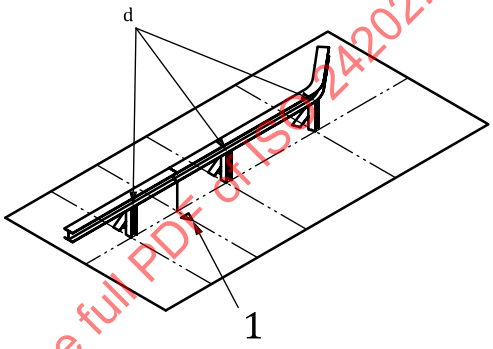
a) Mid span of the longest span



b) Cantilever outer end (larger than 500 mm)



c) End and centre of turns



d) Support points as the worst scantling of support

Key

1 block joint to divide monorail beam
L span of monorail beam
R radius as curved monorail beam
a Middle of the longest span.
b End of cantilever.
c End of radius and centre of radius.
d Worst scantling support to be selected through supporting points.

Figure 5 — Test positions of monorail beams

5 Requirements and specifications for padeyes

5.1 General

This clause specifies the minimum requirements for the design and testing of padeyes made from steel plates as per material data sheet in Annex A. This specification applies to padeyes only. This clause does not apply to supporting structures and lifting appliances operating on the padeyes.

The design shall be based on the loads and load effects, which are described by the manufacturer of the specific lifting equipment to be suspended by the padeyes.

5.2 Design loads

The following design loads apply for padeyes:

a) The padeyes safety working load (SWL) shall be designed equal to or larger than the selected shackle SWL.

b) A design load factor (DLF) shall be taken as per Table 3.

c) In-plane sling angle should be limited within ±45°.

d) Padeyes operating out-of-plane angle are not permitted. Only for design, out-of-plane load for padeyes is considered as 5 % of design load including DLF. If any out-of-plane angle for padeyes is applied, out-of-plane load with 5 % design margin shall be considered.

Table 3 — Design load factor depending on SWL

SWL	DLF for LRFD	DLF for ASD
SWL ≤ 3 t	2,52	1,74
SWL > 5 t	2,18	1,51

NOTE 1 DLF for LRFD is based on DAF and DF.

NOTE 2 DLF for ASD is converted from DLF for LRFD considering safety factor (0,6) and material resistance factor (1,15).

NOTE 3 In the proposed DLF, the dynamic amplification factor (DAF) has been taken as 1,5 for SWL up to and including 3 t and 1,3 for SWL above 5 t. For SWL between 3 t and 5 t, DAF is to be found by linear interpolation.

NOTE 4 Design factor (DF) is defined as partial load factor multiplied with consequence factor. For design of padeyes, DF 1,68 is considered as single critical elements.

5.3 Fabrication

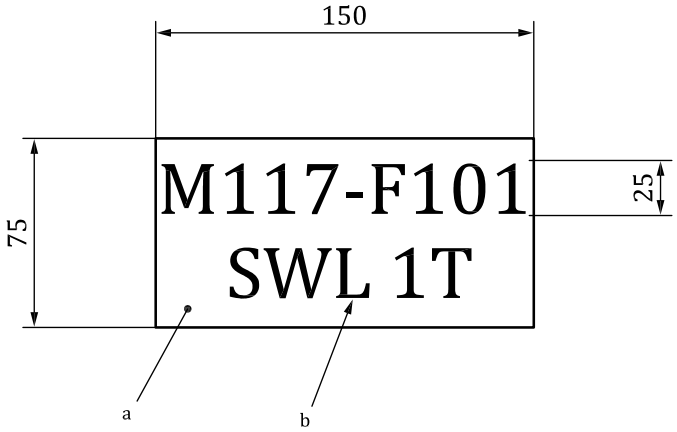
Fabrication tolerances of the opening size and thickness shall be in accordance with the specification given by the shackle manufacturer.

5.4 Painting and marking

Padeyes shall be painted yellow and shall be permanently marked with a unique identification and SWL visible from floor level with a font size to be minimum 25 mm high.

Marking of a 0,5 mm thick PVC plate with double side acrylic foam tape can be applied as shown in Figure 6.

Dimensions in millimetres



a Yellow background colour.

b Black letter colour.

Figure 6 — Example of PVC plate with double side acrylic foam tape

5.5 Material grade and design temperature

The design class of padeyes shall be considered as DC4 in accordance with the design class approach of ISO 19902. The failure of padeyes for material handing purpose only will not have substantial consequences, because these are local structures from overall topside strength aspects. Padeyes are mainly axial stress pattern without out-of-plane operating.

Allowable thicknesses for each material grade of padeyes shall be determined per Table 4 based on design temperature. If the design temperature for the unit is lower than –20 °C, the material grades for padeyes are not covered by this document.

Table 4 — Allowable thickness of padeyes based on design temperature

Steel grade	Design temperature		
	0 °C	–10 °C	–20 °C
P355-0	up to 25 mm	up to 20 mm	up to 15 mm
P355-20	up to 50 mm	up to 40 mm	up to 30 mm
P355-40	-	-	up to 60 mm

5.6 Specification of shapes and dimensions

The specified shapes and dimensions of padeyes for each SWL as shown in Figure 7 and Table 5 are based upon the design load specified in 5.2. The specifications are based on shackle dimensions of the most common shackle manufacturers, which are described in Annex B as Type A and B.

For padeyes with SWL above 25 t, a proper design shall be performed in accordance with applicable international standards, e.g. NORSOK R-002.

If other types of padeyes are used, the padeyes shall be designed in accordance with the requirements of this document for design loads, material grade, testing and inspection.

Detailed specifications of shapes and dimensions of padeyes specified in this document may be referred to when designing other types of padeyes.

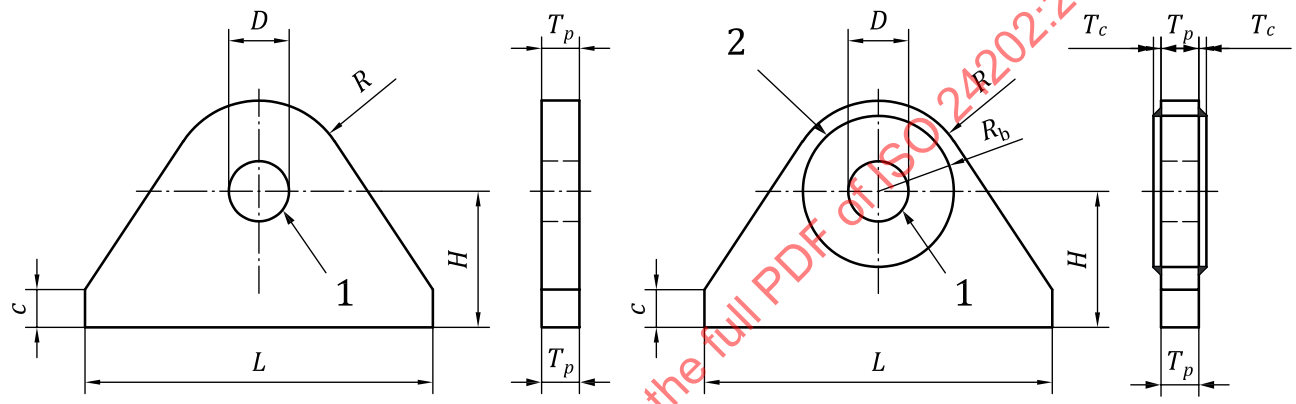
Partial joint penetration (PJP) welding shall be applied for padeyes up to 35 mm thickness. For 15 mm thickness and less, fillet welding can be applied.

Lap joint welding can be considered for padeyes less than SWL 1 t.

Complete joint penetration (CJP) welding shall be applied for frequently operated padeyes when the number of cycles exceeds 20 000 times during an operating life of the unit.

UT cannot be fully applied for CJP welding for the specified shapes and dimensions of padeyes in this subclause due to insufficient plate height at the edges of the padeyes. To meet UT requirements for welding inspection, dimension "c" of toe height of padeyes shall be at least 3,5 times to 4,0 times of its thickness.

The padeyes with cheek plates shall be line bored after welding is completed.



a) Type 1 single padeye **b) Type 2 padeye with cheek plates**

Key

1 drill hole

2 cheek plate

NOTE See Table 5.

Figure 7 — Configuration of padeye for Type 1 and Type 2

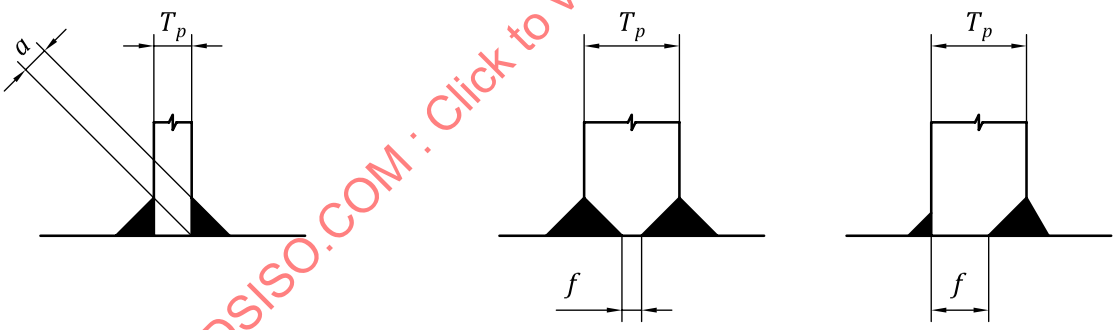
Table 5 — Detailed specifications of shapes and dimensions of padeyes (Type 1 and 2)

SWL (t)	Type	Dimensions of padeyes (mm)									
		T_p	T_c	D	R	R_b	H	L	c	b	a
1,0	1	15,5	-	12,5 (12,0)[a]	20,0	-	30,0	80,0	14,0	-	8,0
2,0		18,0	-	17,5	26,0	-	45,0	110,0	18,0	-	PJP
3,25		25,0	-	21,0	30,0	-	50,0	125,0	22,0	-	PJP
4,75		25,0	-	24,0	35,0	-	60,0	140,0	25,0	-	PJP
6,5		30,0	-	27,5	38,0	-	65,0	160,0	30,0	-	PJP
8,5		35,0	-	31,0 (30,0)[a]	42,0	-	70,0	180,0	35,0	-	PJP
9,5		35,0	-	34,0	47,0	-	80,0	200,0	35,0	-	PJP
12,0	2	25,0	8,0	39,0	60,0	52,0	88,0	220,0	25,0	5	PJP
13,5		25,0	10,0	42,0	66,0	56,0	95,0	236,0	25,0	7	PJP
17,0		30,0	10,0	47,0	71,0	61,0	103,0	258,0	30,0	7	PJP
25,0		35,0	12,0	55,0	84,0	72,0	121,0	302,0	35,0	7	PJP

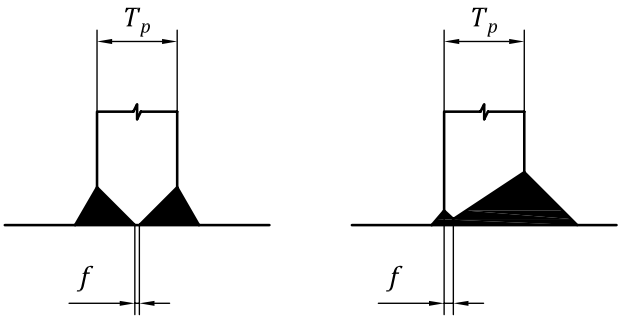
[a] Bracket diameter for hole is based on shackle data Type B as shown in Annex B.

[b] The above standard hole size and thickness for padeyes are designed based on most common shackle manufacturer data as shown in Annex B. In case the selected shackle is different respect to what has been reported in Annex B, a proper design shall be performed in accordance with applicable international standards, e.g. NORSOK R-002.

NOTE Throat thickness of fillet weld or PJP weld. See Figure 8 for detail information.



a) Fillet welding **b) Partial joint penetration welding**



c) Complete joint penetration welding

Key

T_p padeye thickness

a throat thickness

f root face, for PJP, 0 to 1/3 T_p, for CJP, 0 to 2 mm

Figure 8 — Detail welding drawing for padeye connection to supporting structures

5.7 Load test requirements

Each padeye shall be subject to a proof load test as 1,25 times of SWL.

The test load shall be applied on the hole of the padeye using a shackle.

The detailed testing and inspection requirements are provided in Clause 6.

6 Testing and inspection

6.1 General

This clause specifies the requirements for testing and inspection of monorail beams and padeyes.

The loads shall be measured by a load cell calibrated by ISO 7500-1 or other recognized standard, such that the sum of the inaccuracies of the load and load cell do not exceed ±2 %.

All monorail beams and padeyes should be carried out 100 % of load testing using proof test loads as 1,25 times of SWL.

Minimum load test duration is at least 5 min after the load reading has stabilized.

The quality control plan for the structural load test of monorail beams and padeyes is denoted in Annex C for checklist and examples of test sheet.

For reference, detailed test methods are descripted in Annex D.

6.2 Sampling test

Sampling test through design verification instead of 100 % load testing can be applied.

6.3 Sampling test for monorail beams

For series of identical monorail beams, the number of tests by sampling test can be selected in accordance with Table 6.

Table 6 — Sample selection for proof load testing of monorail beams

Number in series	Number to be tested
1 to 3	All
4 to 6	3
7 to 10	4
11 to 15	5
16 to 25	6
26 to 40	8
> 40	To be discussed

Regarding definition of series, the following parameters should be considered:

a) same monorail beam size;

b) same or less SWL;

c) same or similar support conditions for monorail beam.

6.4 Sampling test for padeyes

Considering total number of padeyes on each project and design margin for padeyes, the number of tests by sampling test for series of identical padeyes can be selected in accordance with Table 7.

Table 7 — Sample selection for proof load testing of padeyes

SWL	Design verification	Test number
SWL ≤ 1 t	100 %	No test
1 t < SWL ≤ 3,25 t	100 %	10 %
3,25 t < SWL ≤ 10,0 t	100 %	50 %
SWL > 10,0 t	100 %	100 %

Regarding definition of series, the following parameter should be considered:

a) same size and dimension of padeye;

b) same or similar support conditions.

6.5 Prerequisite for testing

All joints, connections and supports shall be inspected and recorded before load test. The load used shall be made up of certified weight.

A measuring instrument, such as tension meter and load cell, shall have valid calibration certificate within twelve months. When tension meter is used, the electric magnet shall be installed at a test position.

The flange of monorail beams shall be protected by proper means to avoid bending and deformation.

NDT shall be conducted before and after load testing. Weld joints shall be free from any paint for the NDT before and after the load test. Once the NDT has been completed, the weld joints shall be painted in accordance with the painting specification.

Range of tension meters:

— SWL < 6 t : 15 t capacity tension meter;

— 6 t ≤ SWL < 20 t : 50 t capacity tension meter;

— 20 t ≤ SWL : Gantry cranes or other method.

Range of load cells:

— 1 t ≤ SWL < 11 t : 5 t to 15 t capacity load cell;

— 11 t ≤ SWL < 23 t : 15 t to 30 t capacity load cell;

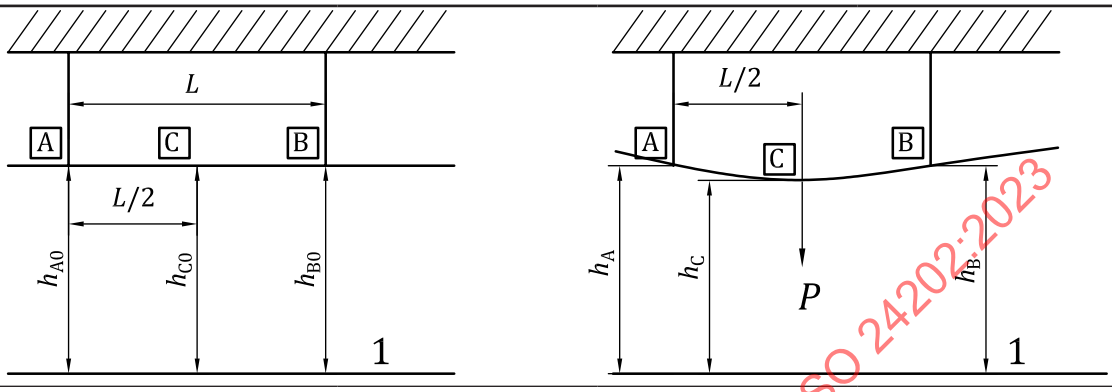
— 20 t ≤ SWL < 40 t : 30 t to 50 t capacity load cell;

— 40 t ≤ SWL : 50 t to 125 t capacity load cell.

6.6 Test result evaluation

After load testing of monorail beam, permanent deformation shall not be allowed. All monorail beams shall be measured for deflection in accordance with the criteria in Tables 8 and 9.

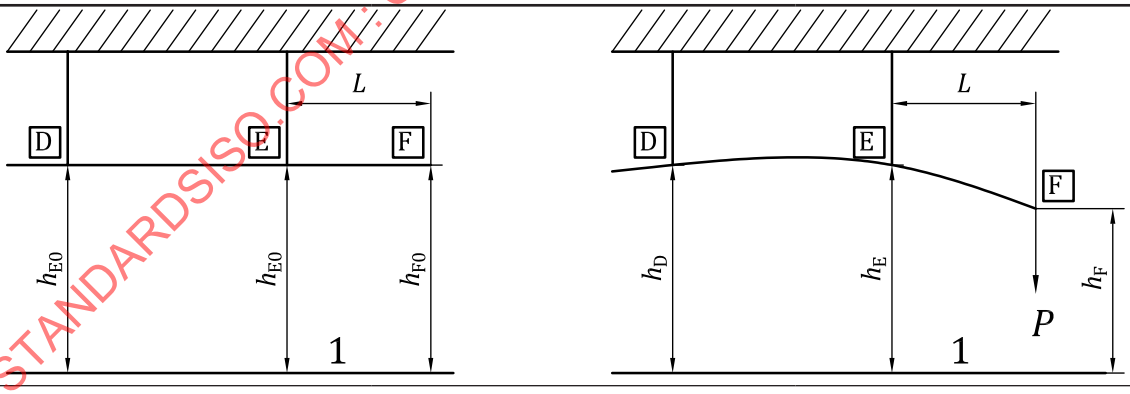
Table 8 — Load test criteria for monorail beam between two supports



1 Deck

	Support points		Load point
	A	**B**	**C**
Elevation without load	h_{A0}	h_{B0}	h_{C0}
Elevation with load	h_A	h_B	h_C
Displacement	$d_A = h_{A0} - h_A$	$d_B = h_{B0} - h_B$	$d_C = h_{C0} - h_C$
Deflection	$\delta = d_C - (d_A + d_B) / 2$		
Allowable deflection	$\delta_{allow} = L / 500$		
Criteria	$\delta \leq \delta_{allow}$		

Table 9 — Load test criteria for monorail beam at cantilever

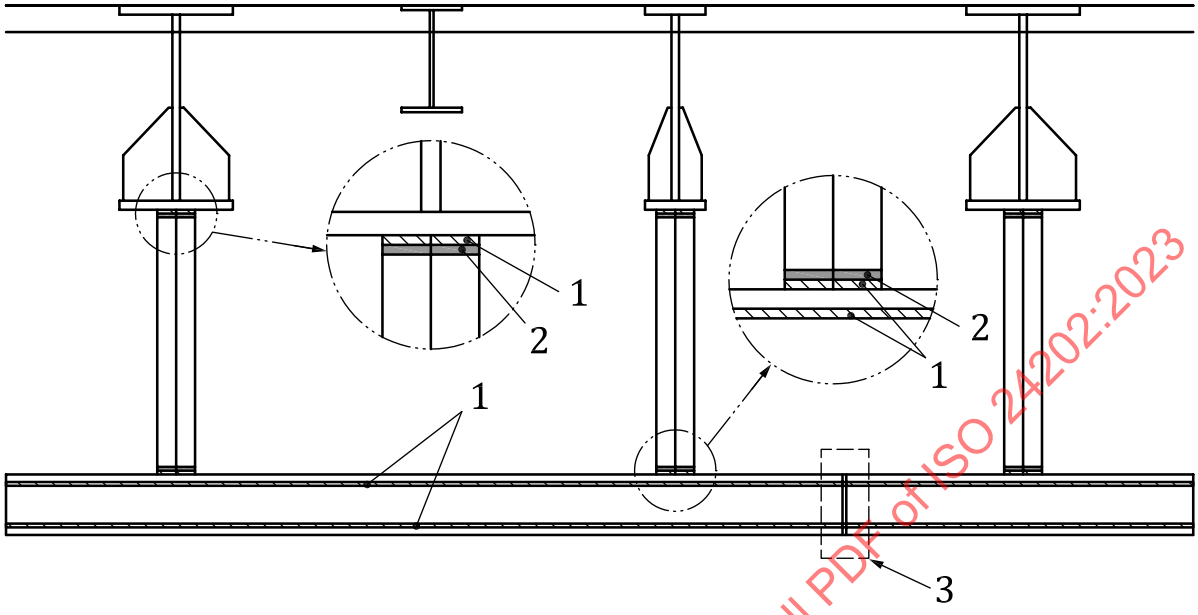


1 Deck

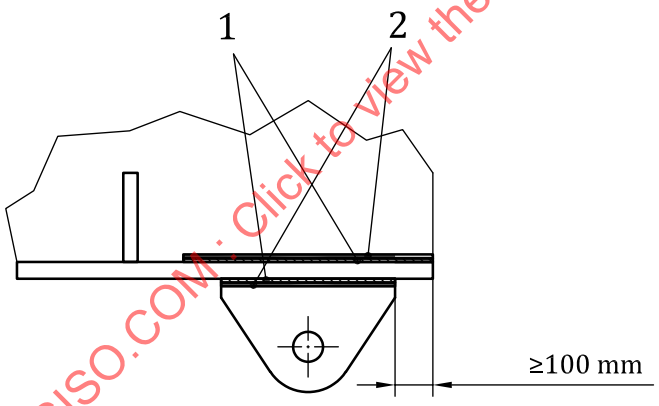
	Support point	Load point
	E	**F**
Elevation without load	h_{E0}	h_{F0}
Elevation with load	h_E	h_F
Displacement	$d_E = h_{E0} - h_E$	$d_F = h_{F0} - h_F$
Deflection	$\delta = d_F - d_E$	
Allowable deflection	$\delta_{allow} = L / 250$	
Criteria	$\delta \leq \delta_{allow}$	

6.7 Inspection

NDE shall be carried out on all welding connections subject to load impacts on monorail beams and padeyes as shown in Figure 9.



a) Inspection requirements for monorail beams including supporting structures



b) Inspection requirements for padeyes including supporting structures

Key

1 For fillet and PJP welding, 100 % VT + MPI before load test.
For CJP welding, 100 % VT + MPI + UT before load test.

2 For fillet and PJP welding, 100 % VT + MPI after load test, UT can be required, if further investigation is required based on VT + MPI.
For CJP welding, 100 % VT + MPI after load test, UT can be required, if further investigation is required based on VT + MPI.

3 For butt welds on monorail beam, 100 % UT before load test shall be performed.

Figure 9 — Non-destructive examination (NDE) requirement

Annex A
(normative)

Material requirements for monorail beams and padeyes

A.1 Manufacturing

The steel shall be made by the oxygen or basic electric arc furnace process involving secondary refining. All steel shall be fully killed and produced to fine grain practices.

Steel shall be cast in metal ingot moulds or by continuous casting. Sufficient discard shall be made to ensure soundness in the finished product.

Minimum sectional reduction ratio of semi-product (e.g. slab, bloom) to final product shall not be less than 6 to 1.

During the normalizing or quench and temper heat treatment, the temperature uniformity in the furnace shall be monitored and recorded. Heat treatment equipment shall be inspected regularly to ensure that uniform heating can be achieved and maintained. Thermocouples and recording equipment shall be calibrated.

A.2 Testing and inspection

A.2.1 Chemical composition

The chemical composition of each ladle shall be analysed on a sample taken during pouring. The analysis result shall fulfil the requirements in the MDS. Intentional addition of B (Boron) is not permitted.

Residual elements shall be determined and reported. The chemical contents shall not exceed the following: 0,30 % Cu, 0,25 % Cr, 0,03 % As, 0,01 % Sb, 0,02 % Sn, 0,01 % Pb, 0,01 % Bi, 0,005 % Ca and 0,000 5 % B.

The steel shall contain the grain refining elements Al, Nb, V or Ti, either singly or in any combination, taking into account the following conditions:

a) when used singly, the steel shall contain the specified minimum content of the following elements: Al (total): min. 0,015 %, Ti: 0,007 to 0,05 %, Nb: 0,02 to 0,05 %, V: 0,05 to 0,10 %

b) when Al and Nb are used in combination, total Al ≥ 0,015 % and Nb: 0,010 to 0,05 %;

c) when Al and V are used in combination, total Al ≥ 0,015 % and V: 0,030 to 0,10 %

d) (Nb+V+Ti) ≤ 0,11 % and Nb + V < 0,08 %.

Carbon equivalent value (Ceq.) and Crack susceptibility factor (Pcm) are calculated in accordance with the following formulae:

$$Ceq. = C + Mn / 6 + (Cr + Mo + V) / 5 + (Ni + Cu) / 15$$

$$Pcm = C + Si / 30 + (Mn + Cu + Cr) / 20 + Ni / 60 + Mo / 15 + V / 10 + 5B$$

A.2.2 Mechanical test

A.2.2.1 Test specimens

Mechanical tests specimens shall be taken at the square cut end of the piece at 1/3 width (one-third of flange) from a long edge.

Samples and test pieces shall be marked so that the original products and their location and orientation in the product are known.

A.2.2.2 Testing

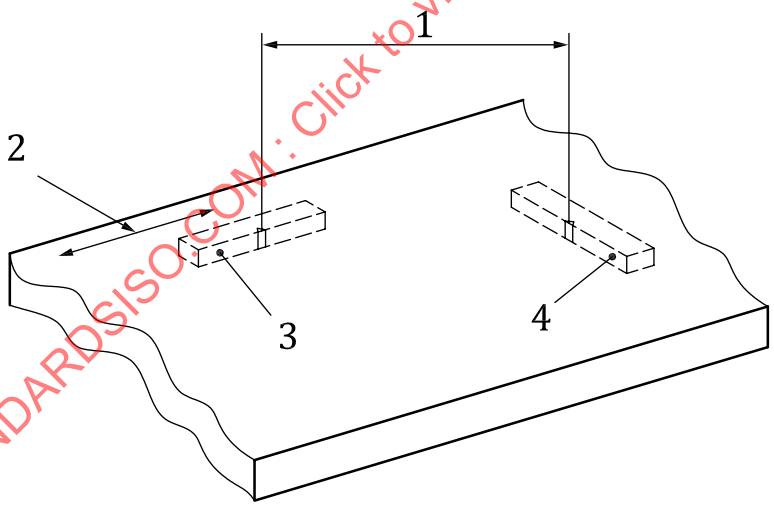
Tests are to be carried out as follows:

a) Tensile test shall be in accordance with ISO 6892-1 or ASTM A370. Specimens shall be cut with their longitudinal axis parallel to the principal direction of rolling. The specified elongation is based on gauge length of $5{,}65\sqrt{So}$. When other gauge lengths are used, the minimum required value shall be converted in accordance with ISO 2566-1.

b) Specimens shall be transverse to principal direction of rolling. When it is impossible to take the test specimen from the transverse direction (e.g. narrow flange width), a specimen may be taken in the longitudinal direction upon agreement with the purchaser. Test specimens shall be taken at 1/4 thickness. Impact testing for material less than 6 mm thick are not required.

The minimum average impact value is given in the MDS. No individual impact value shall be less than 70 % of the minimum average value. The reduction factors of energy requirements for sub-size specimens shall be 5/6 for 7,5 mm and 2/3 for 5 mm.

The location of test specimens for different type of sections are shown in Figures A.1 and A.2.



Key

1 axis of V-notch
2 rolling direction
3 longitudinal test piece
4 transverse test piece

Figure A.1 — Location of test specimens from plates

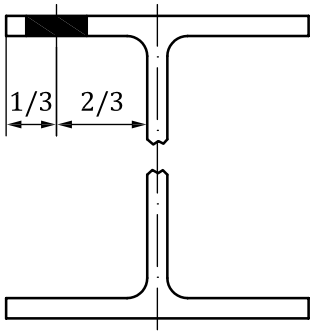


Figure A.2 — Location of test specimens from H-beams

A.2.2.3 Retesting

When the tensile test results fail to meet requirements, two additional tests specimens from the same sample may be tested. If both additional tests are satisfactory, the unit may be accepted.

When the results from a set of three impact test specimens fail to meet the requirements, three additional test specimens from the same sample may be tested. The results are added to those previously obtained. The test unit may be accepted if the following conditions are met:

a) the average of all six specimens conforms with the requirements;

b) not more than two individual results are lower than the required average;

c) of these, not more than one result is below 70 % of the specified average value.

If unsatisfactory results are obtained from retests representative of a test unit, the sample product from which the tests were made shall be rejected.

A.3 Inspection

Products shall have a workmanlike finish consistent with the manufacturing method and shall be free from internal and surface defects detrimental to the use of the material for the intended application.

A.4 Repair

Surface defects may be removed by grinding provided that the remaining thickness is within the under-thickness tolerances of the plates and sections in question. Where necessary, the entire surface may be ground to a depth as given by the under-thickness tolerances of the product.

Repair of surface defects by welding is not allowed by the steel manufacturer.

A.5 Identification

Durable marking shall be applied on at least one location with the following information:

a) manufacturer's name or trademark;

b) steel grade (e.g. S355-20);

c) a suffix indicating the delivery condition as below;

— normalizing rolling (NR): controlled rolling procedure where the final rolling temperature is controlled within the same temperature range as for conventional furnace normalizing;

— normalising (N): separate heat treatment after rolling involving austenitizing and air cooling to produce a fine-grained ferrite-pearlite microstructure;

— thermo-mechanically controlled process (TM): rolling procedure in which rolling temperatures, reduction ratios and accelerated cooling conditions are controlled;

d) identification number, heat number or other marking which will enable the full history of the product to be traced;

e) any other information required by the purchaser.

A.6 Material data sheets

Otherwise agreed between user and manufacturer, requirements for monorail beams and padeyes shall be in accordance with Tables A.1 to A.5.

Table A.1 — Material data sheet for monorail beams with material grade S355-20

MATERIAL DATA SHEET Structural steel sections for monorail beams		MDS – M001 Rev.0 Material Gr.: S355-20
1.	**Reference (informative)**	EN 10025-2 S355K2/J2 EN 10025-3 S355N, S355NL EN 10025-4 S355M, S355ML API 2MT2 Class A ASTM A572 Gr. 50 IACS W8 D36
2.	**Scope**	This MDS specifies material requirements for sections for monorail beams. These grades shall not be used for thicknesses above 25 mm.
3.	**Delivery condition**	NR, N or TM
4.	**Chemical composition (wt. %)**	C: max. 0,18, Si: max. 0,50, Mn: max. 1,60, P: max. 0,030, S: max. 0,025 Ceq.: max. 0,43, Pcm: max. 0,23 Residual elements and refining elements are specified in A.2.1.
5.	**Mechanical property**	Tensile strength, Rm in MPa: 470 to 630 Yield strength, ReH in MPa: min. 355 Elongation (%, Lo = 5,65√So): min. 22 Impact (2-v notch, transverse, at –20 °C): min. avg. 42 J, ind. 29 J
6.	**Extent of testing (test unit)**	1 tensile + 1 set of 3 impact test per heat (max. 40 t).
7.	**Surface condition**	All surfaces shall be visual inspected and unless otherwise agreed, for surface soundness EN 10163-3 Class C sub-class 3 is applied.
8.	**Dimension and shape**	Unless otherwise agreed between purchaser and manufacturer, dimensions and tolerances are applied in accordance with relevant standards.
9.	**Identification**	MDS number, material grade, heat number, other product traceability, if applicable. Other number as per purchaser's request.
10.	**Type of certificate**	Material certificate shall be issued in accordance with EN 10204 type 3.1 or ISO 10474 type 3.1.

Table A.2 — Material data sheet for monorail beams with material grade S355-40

MATERIAL DATA SHEET Structural steel sections for monorail beams		MDS – M002 Rev.0 Material Gr.: S355-40
1.	**Reference (informative)**	EN 10225 S355MLO, S355ML1O API 2MT2 Class A IACS W8 E36
2.	**Scope**	This MDS specifies material requirements for sections for monorail beams. These grades shall not be used for thicknesses above 40 mm.
3.	**Delivery condition**	NR, N or TM
4.	**Chemical composition (wt. %)**	C: max. 0,18, Si: max. 0,50, Mn: max. 1,60, P: max. 0,030, S: max. 0,015 Ceq.: max. 0,43, Pcm: max. 0,23 Residual elements and refining elements are specified in A.2.1.
5.	**Mechanical property**	Tensile strength, Rm in MPa: 470 to 630 Yield strength, ReH in MPa: min. 355 Elongation (%, Lo = 5,65√So): min. 22 Impact (2-v notch, transverse, at −40 °C): min. avg. 35 J, ind. 25 J
6.	**Extent of testing (test unit)**	1 tensile + 1 set of 3 impact test per heat (max. 40 t).
7.	**Surface condition**	All surfaces shall be visual inspected and unless otherwise agreed, for surface soundness EN 10163-3 Class C sub-class 3 is applied.
8.	**Dimension and shape**	Unless otherwise agreed between purchaser and manufacturer, dimensions and tolerances are applied in accordance with relevant standards.
9.	**Identification**	MDS number, material grade, heat number, other product traceability, if applicable. Other number as per purchaser's request.
10.	**Type of certificate**	Material certificate shall be issued in accordance with EN 10204 type 3.1 or ISO 10474 type 3.1.

Table A.3 — Material data sheet for padeyes with material grade P355-0

MATERIAL DATA SHEET Structural steel plate for padeyes		MDS – PE01 Rev.0 Material Gr.: P355-0
1.	**Reference (informative)**	EN 10025-2 S355J0 API 2H Gr. 50 ASTM A572 Gr. 50 JIS G3106 SM490YB IACS W11 A36
2.	**Scope**	This MDS specifies material requirements for padeyes. This grade shall not be used for thicknesses above 50 mm.
3.	**Delivery condition**	NR, N or TM
4.	**Chemical composition (wt. %)**	C: max. 0,18, Si: max. 0,45, Mn: max. 1,60, P: max. 0,020, S: max. 0,015 Ni: max. 0,40, Mo: max. 0,08, Ceq.: max. 0,43, Pcm: max. 0,23. Other residual elements and refining elements are specified in A.2.1.

Table A.3 *(continued)*

MATERIAL DATA SHEET Structural steel plate for padeyes		MDS – PE01 Rev.0 Material Gr.: P355-0
5.	**Mechanical property**	Tensile strength, Rm in MPa: 470 to 630 Yield strength, ReH in MPa: min. 355 ReH/Rm: max. 0,87 Elongation (%, gauge length of 5,65√So): min. 23 Impact (2-v notch, at 0 °C): min. avg. 35J, ind. 25J
6.	**Extent of testing (test unit)**	1 tensile + 1 set of 3 impact test per heat
7.	**Non-destructive test**	Internal soundness shall be tested with UT in accordance with agreed procedure, or EN 10160 S0/E1 or ASTM Level A.
8.	**Surface condition**	All surfaces shall be 100 % visually inspected. The surface condition shall conform to EN 10163-2, Class A, sub-class 3.
9.	**Thickness**	Thickness is measured in accordance with Clause 6. Unless otherwise specially agreed with purchaser, the minus tolerance on thickness of products in accordance with ISO 7452 class B is 0,3 mm irrespective of nominal thickness.
10.	**Identification**	MDS number, material grade, heat number, plate ID number. Other number as per purchaser's request.
11.	**Type of certificate**	Material certificate shall be issued in accordance with EN 10204 type 3.1 or ISO 10474 type 3.1.

Table A.4 — Material data sheet for padeyes with material grade P355-20

MATERIAL DATA SHEET Structural steel plate for padeyes		MDS – PE02 Rev.0 Material Gr.: P355-20
1.	**Reference (informative)**	EN 10025-2 S355K2 API 2W Gr. 50 API 2Y Gr. 50 API 2H Gr. 50 IACS W11 D36
2.	**Scope**	This MDS specifies material requirements for padeyes. This grade shall not be used for thicknesses above 50 mm.
3.	**Delivery condition**	NR, N or TM
4.	**Chemical composition (wt. %)**	C: max. 0,16, Si: max. 0,45, Mn: max. 1,60, P: max. 0,020, S: max. 0,025 Ni: max. 0,40, Mo: max. 0,08, Ceq.: max. 0,43, Pcm: max. 0,22. Other residual elements and refining elements are specified in A.2.1.
5.	**Mechanical property**	Tensile strength, Rm in MPa: 470 to 630 Yield strength, ReH in MPa: min. 355 ReH/Rm: max. 0,87 Elongation (%, gauge length of 5,65√So): min. 23 Impact (2-v notch, at –20 °C): min. avg. 50J, ind. 35J
6.	**Extent of testing (test unit)**	1 tensile + 1 set of 3 impact test per heat.
7.	**Non-destructive test**	Internal soundness is to be tested with UT in accordance with agreed procedure, or EN 10160 S0/E1 or ASTM Level A.

Table A.4 *(continued)*

MATERIAL DATA SHEET Structural steel plate for padeyes		MDS – PE02 Rev.0 Material Gr.: P355-20
8.	**Surface condition**	All surfaces shall be 100 % visually inspected. The surface condition shall conform to EN 10163-2, Class A, sub-class 3.
9.	**Thickness**	Thickness is measured in accordance with Clause 6. Unless otherwise specially agreed with purchaser, the minus tolerance on thickness of products in accordance with ISO 7452 class B is 0,3 mm irrespective of nominal thickness.
10.	**Identification**	MDS number, material grade, heat number, plate ID number. Other number as purchaser's request.
11.	**Type of certificate**	Material certificate shall be issued in accordance with EN 10204 type 3.1 or ISO 10474 type 3.1.

Table A.5 — Material data sheet for padeyes with material grade P355-40

MATERIAL DATA SHEET Structural steel plate for padeyes		MDS – PE03 Rev.0 Material Gr.: P355-40
1.	**Reference (informative)**	EN 10225-2 S355NLO (S355G7+N, S355G9+N), S355MLO (S355G7+M, S355G9+M) API 2W Gr. 50 API 2Y Gr. 50 API 2H Gr. 50 IACS W11 E36
2.	**Scope**	This MDS specifies material requirements for padeyes. This grade shall not be used for thicknesses above 100 mm.
3.	**Delivery condition**	N or TM
4.	**Chemical composition (wt. %)**	C: max. 0,16, Si: max. 0,45, Mn: max. 1,60, P: max. 0,015, S: max. 0,015 Ceq.: max. 0,40, Pcm: max. 0,22 Residual elements and refining elements are specified in A.2.1.
5.	**Mechanical property**	Tensile strength, Rm in MPa: 490 to 630 Yield strength, ReH in Mpa: min. 355 ReH/Rm: max. 0,87 Elongation (%, gauge length of $5{,}65\sqrt{S_o}$): min. 23 Impact (2-v notch, at −40 °C): min. avg. 50J, ind. 35J
6.	**Extent of testing (test unit)**	1 tensile + 1 set of 3 impact test per heat (max. 40 t).
7.	**Non-destructive test**	Internal soundness is to be tested with UT in accordance with agreed procedure, or EN 10160 S0/E1 or ASTM Level A.
8.	**Surface condition**	All surfaces shall be 100 % visually inspected. The surface condition shall conform to EN 10163-2, Class A, sub-class 3.
9.	**Thickness**	Thickness is measured in accordance with Clause 6. Unless otherwise specially agreed with purchaser, the minus tolerance on thickness of products in accordance with ISO 7452 class B is 0,3 mm irrespective of nominal thickness.
10.	**Identification**	MDS number, material grade, heat number, plate ID number. Other number as per purchaser's request.
11.	**Type of certificate**	Material certificate shall be issued in accordance with EN 10204 type 3.1 or ISO 10474 type 3.1.

A.7 Specification of dimension and tolerance

A.7.1 General

Nominal dimension and tolerance for sections are given in this clause.

Specified dimension may be modified upon agreement between purchaser and manufacturer. The values stated in either inch-pound units or SI units (metric) are to be regarded separately as standard.

A.7.2 Recommended dimensions for structural steel H-beams

Figure A.3 and Table A.6 show the dimensions of H-beams for monorail beams as recommended.

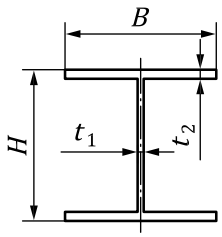


Figure A.3 — Dimension of H-beams

Table A.6 — Recommended dimension of H-beams

H-beam (metric, mm)					**W-shape** (inch)	**HE/IPE** (mm)
Designation	***H***	***B***	t_1	t_2		
H200×200×8×12	200	200	8	12	W8×35	HE220A
H294×200×8×12	294	200	8	12	W12×40	IPE330
H300×300×10×15	300	300	10	15	W12×65	HE300A
H400×200×8×13	400	200	8	13	W16×45	IPE400
H390×300×10×16	390	300	10	16	W16×67	HE400A
H488×300×11×18	488	300	11	18	W18×97	HE500A
H588×300×12×20	588	300	12	20	W24×104	HE600A
H700×300×13×24	700	300	13	24	W24×129	HE700A
H800×300×14×26	800	300	14	26	-	HE800A

This table does not provide exactly equivalent dimension between metric unit size and inch unit size, hence, when selecting alternative size, designer shall consider this and calculate separately.

NOTE The dimensions of H-beam are based on H-beam sizes in EN, ASTM and JIS standards.

Depending on purchaser's requirements, the above dimension may be modified.

A.7.3 Dimension tolerance

Dimension tolerance for H-beams is summarized in Table A.7.

Table A.7 — Dimensional tolerance

Division and dimension, mm			**Tolerance**, mm
Width (B)	$B \leq 400$		±2,0
	$400 < B$		±3,0
Depth (H)	$H < 800$	$B \leq 400$	±2,0
		$400 < B$	±3,0
	$800 \leq H$		±3,0
Web thickness (t_1)	$t_1 < 16$		±0,7
	$16 \leq t_1 < 25$		±1,0
	$25 \leq t_1 < 40$		±1,5
	$40 \leq t_1$		±2,0
Flange thickness (t_2)	$t_2 < 16$		−0,7 to +1,0
	$16 \leq t_2 < 25$		±1,0
	$25 \leq t_2 < 40$		±1,7
	$40 \leq t_2$		±2,0
Length (L)	All size		0 to unlimited

A.7.4 Tolerance of squareness, web off centre and straightness

The following three types of tolerances are distinguished:

a) Squareness tolerance

Squareness tolerance for H-beam is shown in Figure A.4 and Table A.8.

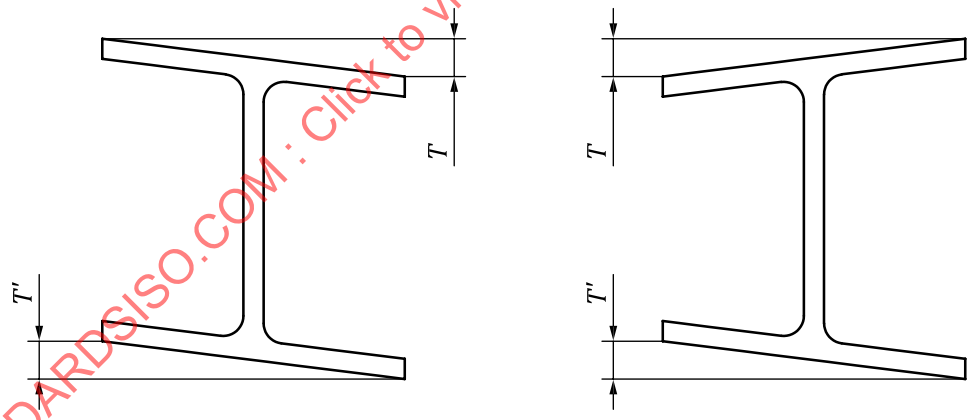


Figure A.4 — Squareness tolerance of H-beam

Table A.8 — Squareness tolerance

Division and dimension, mm		**Tolerance**, mm
Squareness ($T + T'$)	300 or under in depth H	1,0 % or under of width B, provided that 1,5 mm is the minimum
	Over 300 in depth H	1,2 % or under of width B, provided that 1,5 mm is the minimum

b) Web off centre tolerance

Web off centre tolerance for H-beam is described in Figure A.5 and Table A.9.

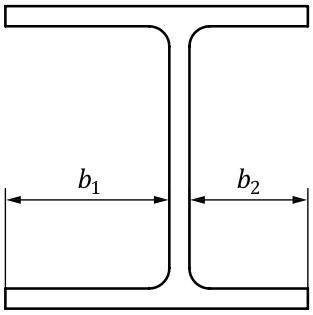


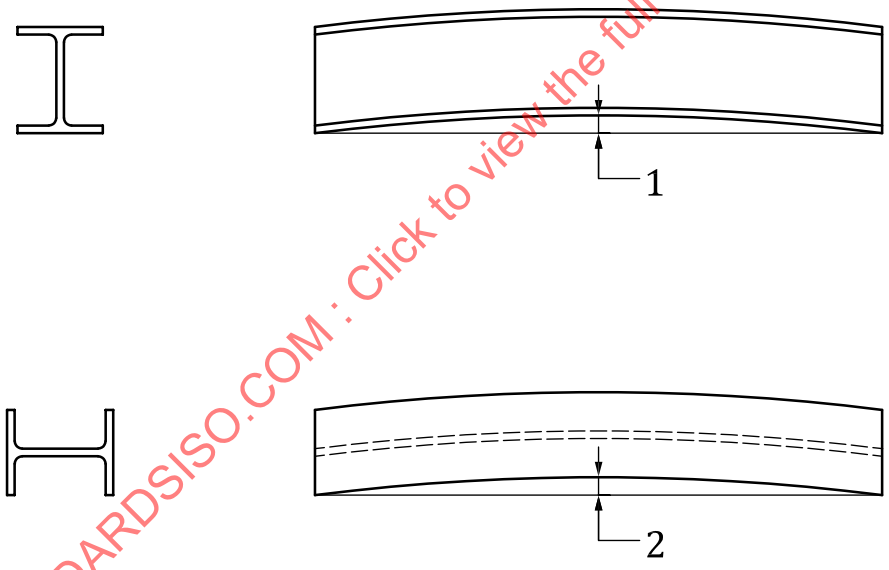
Figure A.5 — Web off centre tolerance of H-beam

Table A.9 — Web off centre tolerance

Division and dimension, mm		**Tolerance**, mm
Web off centre (S)	300 or under in depth H and 200 or in width B	±2,5
where $S = (b_1 - b_2) / 2$	Over 300 in depth H and over 200 in width B	±3,5

c) Straightness tolerance

Straightness tolerance for H-beam is shown in Figure A.6 and Table A.10.



Key

1 camber
2 sweep

Figure A.6 — Straightness tolerance of H-beam

Table A.10 — Tolerance of straightness

Height (*H*), mm	**Tolerance**
$H \leq 180$	0,30 % × length
$180 < H \leq 360$	0,15 % × length
$360 < H$	0,10 % × length

A.8 Material certificate

The inspection certificate shall include the following information:

a) purchaser's name, certificate number and address of manufacturer;

b) manufacturer's name;

c) heat number, product number;

d) description of the product, dimensions, weight, etc.;

e) MDS number and material designation, including delivery condition;

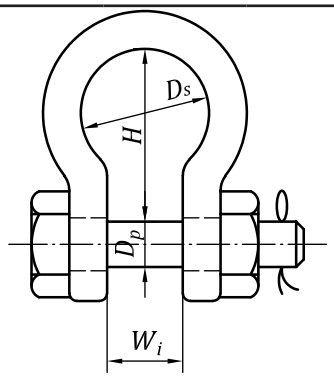
f) ladle analysis for specified elements;

g) results of all specified inspections and mechanical tests;

h) NDT test result, when required.

Annex B
(normative)

Detail shackle data for padeye design



Dimensions in millimetres

SWL (t)	Pin diameter D_p		Inside width at pin W_i		Inside length H		Diameter of shackle inside D_s	
	Type A	Type B	Type A	Type B	Type A	Type B	Type A	Type B
1	11,18	11,00	16,76	17,00	36,58	36,50	26,16	26,00
2	16,00	16,00	20,57	22,00	47,75	51,00	33,27	32,00
3,25	19,05	19,00	26,92	27,00	60,45	64,00	42,93	43,00
4,75	22,35	22,00	31,75	31,00	71,37	76,00	50,80	51,00
6,5	25,40	25,00	36,58	36,00	84,07	83,00	57,91	58,00
8,5	28,70	28,00	42,93	43,00	95,25	95,00	68,33	68,00
9,5	31,75	32,00	45,97	47,00	107,95	108,00	73,91	75,00
12	35,05	35,00	51,56	51,00	119,13	115,00	82,55	83,00
13,5	38,10	38,00	57,15	57,00	133,35	133,00	92,20	92,00
17	41,40	42,00	60,45	60,00	146,05	146,00	98,55	99,00
25	50,80	50,00	73,15	74,00	177,80	178,00	127,00	126,00