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ISO 3077

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Short-link chain for lifting purposes — Grade T, (types T, DAT and DT), fine-tolerance hoist chain

Chaînes de levage à maillons courts — Chaînes de tolérance serrée pour palans, classe T (types T, DAT et DT)

Reference number
ISO 3077:2001(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 3077 was prepared by Technical Committee ISO/TC 111, *Round steel link chains, chain slings, components and accessories*, Subcommittee SC 1, *Chains and chain slings*.

This third edition cancels and replaces the second edition (ISO 3077:1984), which has been technically revised.

Annexes A and B form a normative part of this International Standard. Annex C is for information only.

Short-link chain for lifting purposes — Grade T, (types T, DAT and DT), fine-tolerance hoist chain

1 Scope

This International Standard specifies requirements for fine-tolerance hoist chain of Grade T (types T, DAT and DT) for use with manually operated or power-driven chain hoists[1)].

It is applicable to electrically welded, round, steel short-link chain, heat-treated and tested in accordance with the general conditions of acceptance of ISO 1834, in the nominal chain size range from 3 mm to 22 mm.

NOTE Type T chain, but not type DAT or DT, may be used in lifting equipment other than chain hoists. Chain of grades TH and VH, intended specifically for use in hand-operated hoists, will be the subject of future International Standards.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 643:—[2)], *Steels — Micrographic determination of the apparent grain size*

ISO 1834, *Short link chain for lifting purposes — General conditions of acceptance*

ISO 4301-1, *Cranes and lifting appliances — Classification — Part 1: General*

ISO 4965, *Axial load fatigue testing machines — Dynamic force calibration — Strain gauge technique*

ISO 6507-1, *Metallic materials — Vickers hardness test — Part 1: Test method*

EN 10002-2:1991, *Metallic Materials — Tensile Testing — Part 2: Verification of the Force Measuring System of the Tensile Testing Machines*

3 Terms and definitions

For the purposes of this International Standard, the terms and definitions given in ISO 1834 and the following apply.

3.1
gauge length
specified multiple pitch length of chain

1) Types DT and DAT possess a surface hardness greater than their core hardness, offering greater resistance to wear, and are for use in power-driven hoists only.

2) To be published. (Revision of ISO 643:1983)

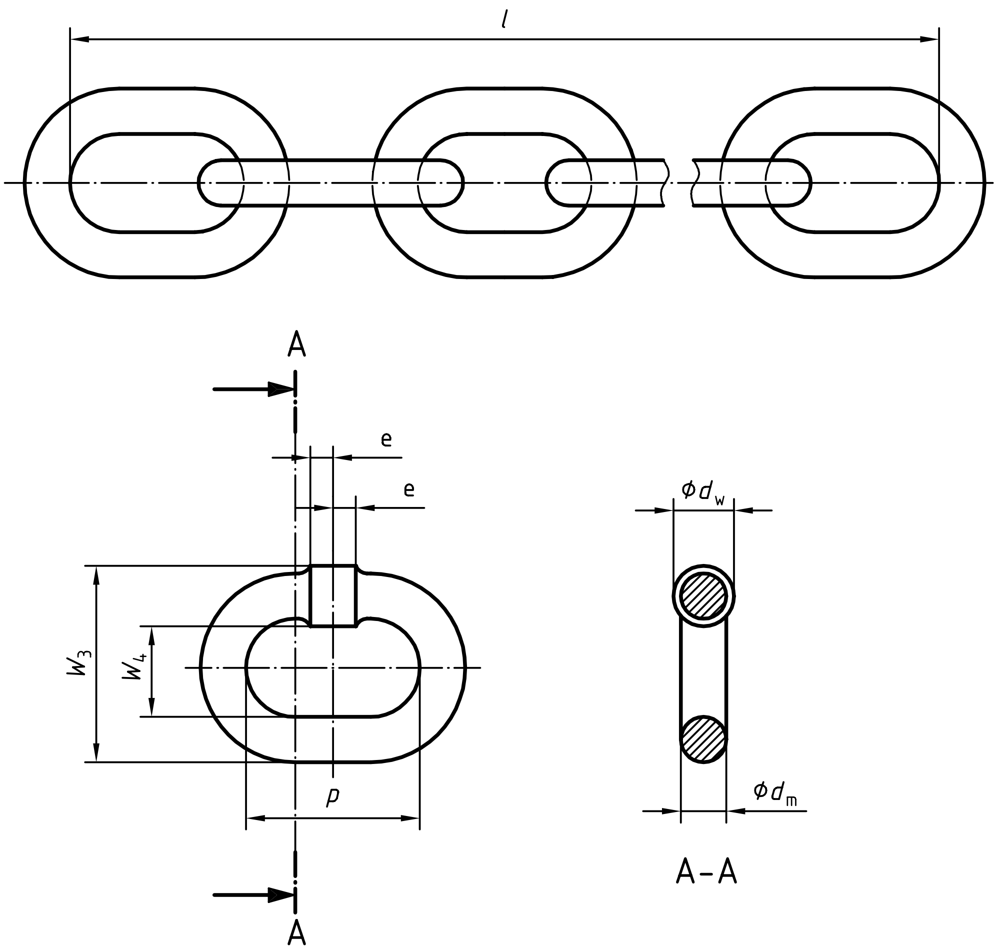
4 General conditions of acceptance

The chain shall comply fully with the requirements of ISO 1834 as well as those of this International Standard.

5 Dimensions (see Figure 1)

5.1 Nominal size, d_n

A selection of nominal sizes is given in Table 1. Other nominal sizes may be used, provided the dimensions and tolerances are calculated in accordance with annex A.



l multiple pitch length

p pitch (internal link length)

d_m measured diameter of the material, except at the weld

d_w measured diameter of the material at the weld

e length affected by welding, on either side of the centre of the link

W_3 external link width over the weld

W_4 internal link width at the weld

Figure 1 — Link and chain dimensions

Table 1 — Typical dimensions

Dimensions in millimetres

Dimension		Pitch		Width		Gauge length $11 \times p_n$		Weld diameter
nominal d_n	tolerance	nominal p_n	tolerance [a]	internal W_4 min.	external W_3 max.	nominal	tolerance [a]	d_w max.
3	± 0,2	9	$^{+0,18}_{0}$	3,6	10,2	99	$^{+0,5}_{0}$	3,3
4	± 0,2	12	$^{+0,25}_{0}$	4,8	13,6	132	$^{+0,6}_{0}$	4,3
5	± 0,2	15	$^{+0,3}_{0}$	6	17	165	$^{+0,8}_{0}$	5,4
6,3	± 0,2	19	$^{+0,4}_{0}$	7,2	20,4	209	$^{+1}_{0}$	6,5
7,1	± 0,3	21	$^{+0,4}_{0}$	8,4	23,8	231	$^{+1,1}_{0}$	7,6
8	± 0,3	24	$^{+0,5}_{0}$	9,6	27,2	264	$^{+1,3}_{0}$	8,6
9	± 0,4	27	$^{+0,5}_{0}$	10,8	30,6	297	$^{+1,4}_{0}$	9,7
10	± 0,4	30	$^{+0,6}_{0}$	12	34	330	$^{+1,6}_{0}$	10,8
11,2	± 0,4	34	$^{+0,7}_{0}$	13,2	37,4	374	$^{+1,8}_{0}$	11,9
12,5	± 0,5	38	$^{+0,8}_{0}$	14,4	40,8	418	$^{+2,0}_{0}$	13
13	± 0,5	39	$^{+0,8}_{0}$	15,6	44,2	429	$^{+2,1}_{0}$	14
14	± 0,6	42	$^{+0,8}_{0}$	16,8	47,6	462	$^{+2,2}_{0}$	15,1
16	± 0,6	48	$^{+0,9}_{0}$	19,2	54,4	528	$^{+2,5}_{0}$	17,3
18	± 0,9	54	$^{+1,0}_{0}$	21,6	61,2	594	$^{+2,9}_{0}$	19,4
20	± 1	60	$^{+1,2}_{0}$	24	68	660	$^{+3,2}_{0}$	21,6
22	± 1,1	66	$^{+1,3}_{0}$	26,4	74,8	726	$^{+3,5}_{0}$	23,8

NOTE In this table, typical dimensions for a range of nominal sizes are given calculated and rounded in accordance with the formulae in annex A, and based upon a nominal pitch of 3 d_n. Other nominal sizes may be used, provided the dimensions and tolerances are calculated in accordance with annex A. While the nominal link pitch is based upon 3 d_n, this may be varied up to a maximum of 3,2 d_n, also subject to the tolerances specified in annex A.

[a] These tolerances are usually divided into + 2/3 and – 1/3 for both the individual link and the standard gauge length.

5.2 Material diameter and tolerance

The definition of material diameter and method of measurement shall be in accordance with ISO 1834, but to the tolerances given in annex A.

The tolerances on material diameter for the selected nominal sizes shall be as given in Table 1. These and all other nominal size material diameter tolerances shall be calculated in accordance with A.1.

5.3 Pitch and widths

The dimensions and tolerances of the pitch and widths of the individual links as shown in Figure 1 shall be calculated in accordance with A.2.

The tolerances of multiple pitch lengths shall be calculated in accordance with A.2 and based on a gauge length of 11 links.

The dimensions and tolerances for the selected nominal sizes shall be as given in Table 1.

The nominal link pitch, p_n, is based upon 3 d_n, where d_n is the nominal size of the chain. This may be varied up to a maximum of 3,2 d_n. Nominal link pitch p_n shall be subject to the tolerances specified in annex A.

5.4 Weld diameter

The maximum diameter at the weld shall not be in excess of 8 % above the nominal diameter in any direction. The maximum diameter at the weld for the selected nominal sizes shall be as given in Table 1. The diameter of the steel at the weld shall nowhere be less than the actual diameter of the steel adjacent to the weld.

5.5 Length dimensionally affected by welding

The length dimensionally affected by welding shall not extend by more than 0,6 d_n on either side of the centre of the link (see Figure 1).

6 Material and manufacture

6.1 Quality of material

6.1.1 Manufacturer's responsibility

Within the limitations given in 6.1.2 to 6.1.5, it shall be the responsibility of the chain maker to select the type of steel to be used so that the finished chain, when suitably heat-treated, complies with the mechanical properties specified in this International Standard.

6.1.2 Type of steel

The steel used shall be produced by the electric process or by an oxygen-blown process.

6.1.3 Deoxidation

The steel shall be fully killed and shall be made in conformity with a suitable deoxidation process in order to obtain an austenitic grain size of 5 or finer when tested in accordance with ISO 643.

6.1.4 Chemical composition

The steel shall contain alloying elements in sufficient quantities so that the finished chain, when heat-treated in accordance with 6.2, complies not only with the mechanical properties specified in this International Standard but also possesses a low temperature ductility and toughness adequate for providing resistance to impact loading.

The steel shall contain nickel and at least one of the other elements in the minimum percentages shown in Table 2.

Table 2 — Chemical composition — Alloying elements

Element	Minimum mass content as determined by cast analysis %		
	T	DAT	DT
Nickel	0,40	0,7	0,9 [a]
Chromium	0,40		
Molybdenum	0,15		

[a] Higher surface hardness, greater case depth, or both, requires a higher nickel content to avoid brittleness.

To ensure that the chain is stabilized against strain-age embrittlement during service, the steel shall contain at least 0,025 % aluminium.

The steel shall contain no more sulfur and phosphorus content than that restricted by the limits given in Table 3.

Table 3 — Sulfur and phosphorus content

Element	Minimum mass content as determined by	
	cast analysis %	check analysis
Sulfur	0,020	0,025
Phosphorus	0,020	0,025
Sum of S + P	0,035	0,045

6.1.5 Finished condition

In its finished condition and as supplied to the chain maker, the steel shall comply with the requirements of 6.1.2 to 6.1.4 as determined by check analysis on the rod, wire or finished link.

6.2 Heat treatment

Hoist chains of all types shall be hardened, case-hardened, or both, from a temperature above the AC3 point and tempered before being subjected to the manufacturing proof force.

6.3 Working load limits (WLL)

Table 4 gives working load limits, calculated on the basis given in annex A, for the selected nominal sizes of all types of chains. For nominal sizes not included in Table 4, the working load limits shall be calculated in accordance with annex A.

Additional stresses imposed on the chain by the operation of power-driven hoists shall be taken into account in selecting the nominal size for a particular application. Annex B shall therefore be used for the calculation.

Table 4 — Working load limits (WLL)

Nominal size d_n	Chain type		
	T	DAT	D
	Working load limits (WLL)		
mm	t		
3	0,28	0,22	0,14
4	0,5	0,4	0,25
5	0,8	0,63	0,4
6,3	1,2	1	0,63
7,1	1,6	1,2	0,8
8	2	1,6	1
9	2,5	2	1,25
10	3,2	2,5	1,6
11,2	4	3,2	2
12,5	5	4	2,5
13	5,3	4,2	2,6
14	6	5	3
16	8	6,3	4
18	10	8	5
20	12,5	10	6,3
22	15	12,5	7,5
Mean stress N/mm^2	200	160	100

6.4 Mechanical properties

6.4.1 Manufacturing proof force (MPF)

All chains shall be subjected to the MPF calculated according to annex A. For the selected nominal sizes, values are as given in Table 5.

NOTE The formula and rounding rules for the calculation are also given in annex A.

6.4.2 Breaking force (BF) and total ultimate elongation A

Samples of hoist chain in the finished condition shall have a breaking force at least equal to that calculated on the basis given in annex A. For the selected nominal sizes, values are given in Table 5.

On completion of the tensile test, the minimum total ultimate elongation shall be in accordance with the values given in Table 6.

Table 5 — Manufacturing proof forces (MPF) and breaking forces (BF)

Nominal size d_n mm	**MPF** kN min.	**BF** kN min.
3	7,1	11,3
4	12,6	20,1
5	19,6	31,4
6,3	31,2	49,9
7,1	39,6	63,3
8	50,3	80,4
9	63,6	102
10	78,5	126
11,2	98,5	158
12,5	123	196
13	133	212
14	154	246
16	201	322
18	254	407
20	314	503
22	380	608

Table 6 — Total ultimate elongation, bend deflection and surface hardness

Parameter		**Chain type**		
		T	DAT	DT
Total ultimate elongation A [a]	% min.	10	10	5
Deflection f	min.	0,8 d_n	— [b]	
Surface hardness[c]	min.			
d_n < 7 mm, HV 5		360	500	550
7 mm ⩽ d_n ⩽ 14 mm, HV 10		360	500	550
d_n > 14 mm, HV 10		360	450	500

a $\frac{\Delta L}{L_o}$

As specified in ISO 1834, except that L_o, the original internal length of the test sample, is used instead of L_n, the nominal internal length.

b See 6.4.3

c Measuring points: see 7.4.

6.4.3 Bend deflection

Single link samples of type T shall withstand the minimum deflection specified in Table 6 and shall be free from visible defects.

Sample links of types DAT and DT shall withstand a force, F_o, equivalent to 2,5 times the working load limit of the chain as given in 6.3 without fracture. A surface crack or visible defect shall not be considered as constituting a fracture.

6.4.4 Surface hardness

The surface hardness at each of the three measuring points as shown in Figure 3 for all types shall be at least equal to the values specified in Table 6.

6.4.5 Case depth

For hoist chain types DAT and DT, the case depth, when measured in accordance with the type test specified in 7.5, shall be within the limits related to nominal size d_n as given in Table 7.

Table 7 — Case depth

Nominal size d_n mm	**Chain type**	
	DAT	DT
< 8	$\geqslant 0{,}03\ d_n \leqslant 0{,}05\ d_n$	$\geqslant 0{,}03\ d_n \leqslant 0{,}06\ d_n$
$\geqslant 8$	$\geqslant 0{,}02\ d_n \leqslant 0{,}04\ d_n$	$\geqslant 0{,}03\ d_n \leqslant 0{,}05\ d_n$

For hoist chain type DAT below 8 mm d_n and hoist chain type DT of all sizes, case depth in the ranges $\geqslant 0{,}02\ d_n \leqslant 0{,}03\ d_n$ and $\geqslant 0{,}025\ d_n \leqslant 0{,}03\ d_n$, respectively, shall be permitted, providing that the surface hardness, measured in accordance with 7.5, exceeds the relevant values in Table 6 by at least 50 points HV.

6.4.6 Fatigue resistance

Hoist chain types DT and DAT shall withstand at least 2×10^6 cycles of application of the stress range specified in 7.6 without failure.

7 Verification of safety requirements

7.1 Size of lot and selection of samples

The size of the lot from which that samples are selected shall be 200 m. An excess fraction of the length of lot shall be considered as a separate lot. For types DAT and DT, if the batch quantity of the furnace is less than 200 m, it shall be considered as a lot. Samples shall be selected according to ISO 1834.

7.2 Manufacturing proof force, breaking force and total ultimate elongation

7.2.1 Static tensile test

The testing machine and test procedure for the static tensile test shall be as specified in ISO 1834.

The equipment used in the tests specified in 7.2.2.2 and 7.3.1 shall comply with Class 1 of EN 10002-2:1991.

7.2.2 Acceptance criteria

7.2.2.1 MPF

All chain shall be subject to the manufacturing proof force specified in 6.4.1.

7.2.2.2 BF and A

On completion of the static tensile test, the requirements of 6.4.2 shall have been met.

7.3 Bend deflection

7.3.1 Bend test

The test equipment and procedure shall be as specified in ISO 1834.

Each single link sample of type T shall be bent by a deflection, f, as given in Table 6 and shown in Figure 2. Single link samples of types DAT and DT shall be correspondingly loaded with force F_o. Following the removal of the force, the link sample shall be examined by a competent person.

Where necessary, a surface coating may be removed after the bend test to enable this examination to be carried out.

7.3.2 Acceptance criteria

On completion of the bend test, the requirements of 6.4.3 shall have been met.

7.4 Hardness test

The number of samples for surface hardness testing shall be related to chain size as specified in ISO 1834 and each sample shall consist of three single links.

Each sample link shall be subjected to surface hardness testing carried out in accordance with ISO 6507-1, with measurements taken at three points as shown in Figure 3, below.

Special jigging shall be used to ensure that the curvature of the link surface does not affect the validity of the measurements taken. Each result shall meet the requirements of 6.4.4.

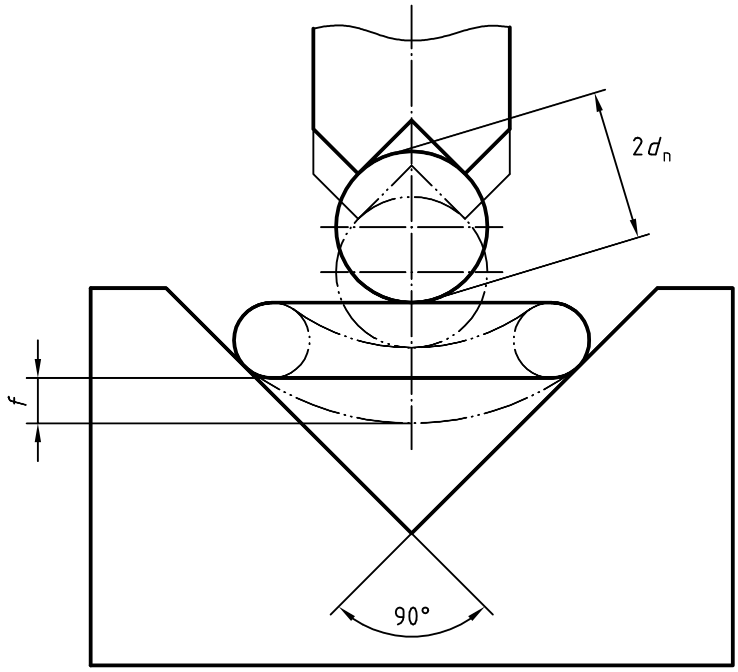


Figure 2 — Bend deflection f

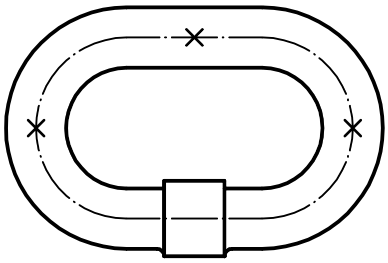


Figure 3 — Hardness test — Measuring points

7.5 Case depth determination

A core hardness type test and determination of case depth shall be carried out on three samples from the initial production of each type and size of chain. If the chemical composition, carburizing conditions or heat treatment for that type and size of chain are subsequently varied outside usual manufacturing tolerances, the type test shall be repeated on three further samples.

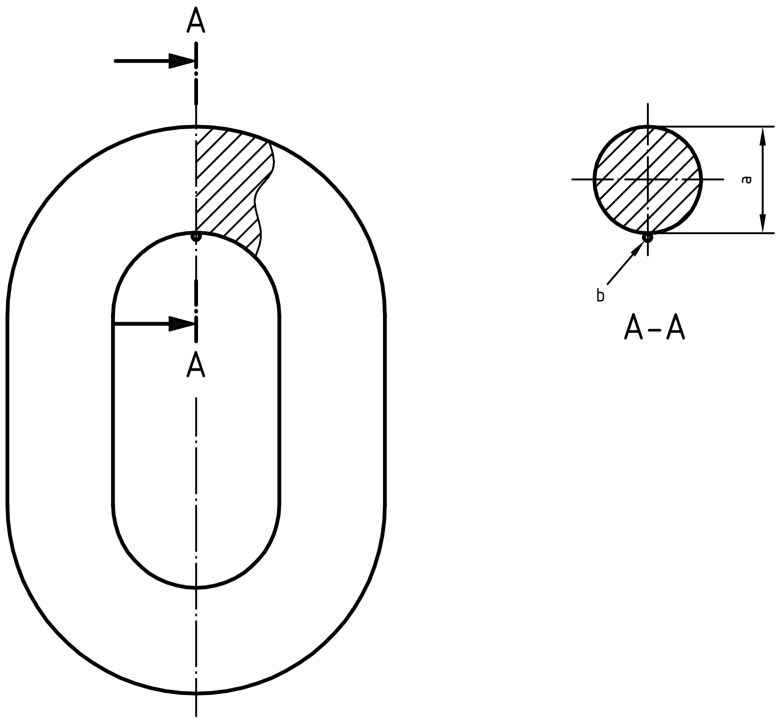
Each of the three separate sample links shall be cut through the crown of the link as indicated in Figure 4 such that the surface to be tested is on the centre line of the link with the intrados identified. Each sample shall be mounted in hard metallographic plastic and prepared to at least a 6 µm finish.

Vickers hardness measurements, using a 5 N test force, shall be carried out inwards from the intrados by a competent person, in accordance with the procedures in ISO 6507-1. Care shall be taken in selecting the longitudinal and lateral spacing of the test impressions to ensure that an accurate plot of hardness against position is obtained. The inward series of measurements shall be continued until it is apparent that a minimum hardness level has been reached.

A reference line shall be constructed on the plot at a level equivalent to 20 points Vickers above the estimated core hardness. The position equivalent to the intersection of this reference line with the plot of hardness against position shall be considered as the total case depth.

The estimated core hardness is the hardness measured at a position equivalent to 3 × 0,06 d_n in from the outer surface.

Each determination of case depth shall meet the requirements of 6.4.5.



a Diameter along which measurements are taken

b Intrados

Figure 4 — Hardness test for case depth determination, link arrangement

7.6 Fatigue resistance test, types DAT and DT

For hoist chain types DAT and DT, a fatigue resistance test shall be carried out for each size of chain. Five five-link samples shall be tested for each size of chain, and at least four of these samples shall meet the requirements stated in 6.4.6. Samples which fail in the area of the clamp shall be discarded.

The stress level applied during each cycle shall be as follows:

— maximum stress level (σ_{max}): 200 N/mm^2;

— mean stress level: 120 N/mm^2;

— minimum stress level (σ_{min}): 40 N/mm^2.

The frequency of the stress applied shall be 5 Hz to 10 Hz, and the testing machine shall comply with ISO 4965 and Class 3 of EN 10002-2:1991.

8 Marking

8.1 Grade marking

The grade mark for the chain is "T", "DAT" or "DT". The marking shall conform to ISO 1834 and the grade mark shall be applied as specified in ISO 1834.

8.2 Identification marking

The identification marking shall be as specified in ISO 1834.

8.3 Inspection marking

The inspection marking shall be as specified in ISO 1834.

9 Manufacturer's certificate

The manufacturer shall, if required, supply a certificate of test and examination with every supply of chain containing the information detailed in ISO 1834.

10 Information for assembly into the hoist and for use

10.1 Chain assembly into the hoist

10.1.1 Selection criteria for hoist chain

Additional stresses imposed on the chain by the operation of power-driven hoists shall be taken into account in selecting the nominal size for a particular application. Annex B shall be used for the calculation.

The rating of the chain shall depend on the particular mechanism group and the chain type (see Table B.1).

10.1.2 Mating parts of the hoist

To ensure smooth running of the chain over the pocket wheels without any unusual impact, both the driven and idle pocket wheels shall be designed to suit the hoist chain.

The chain shall be guided smoothly and without twist into and out of the pocket wheels.

To avoid deformation of the last link of the chain, the chain-connecting parts of the hoist shall be designed so as to permit at least 5 % free movement relative to the inside width of the chain link.

10.2 Chain use

Guidance on the applications for which the different types of hoist chain shall be used is as follows:

— Type T — hand-operated hoists, or power-driven hoists with slow speeds, where the working environment does not involve abrasive conditions;

— Type DAT — power-driven hoists where chain speeds are high, in combination with high working capacity, and where wear resistance is required to give longer chain life;

— Type DT — power-driven hoists used in abrasive conditions.

NOTE Case-hardened chains are not suitable for operation in portable hand-operated hoists.

Hoist chain shall not be used in the manufacture of slings, and the chain in a hoist shall not be used in a basket or choke hitch.

Hoist chain will not be adversely affected by temperatures down to those listed for each grade in Table 8, and no reduction in the working load limit is therefore necessary on this account. Where such chain is to be used at temperatures below those listed, the manufacturer should be consulted.

Table 8 — Lower temperature limits for hoist chain

Chain type	Lower temperature limit °C
T	− 40
DAT	− 20
DT	− 10

Hoist chain types T, DAT and DT can be used up to temperatures of + 200 °C; if the chain reaches a temperature above 200 °C, it should be withdrawn from service and the manufacturer consulted.

Hoist chain should not be used either immersed in acid solutions or exposed to acid fumes. Attention is drawn to the fact that certain production processes involve acid solutions and fumes: in such circumstances the manufacturer's advise should be sought.

For similar reasons, hoist chain should not be galvanized or subjected to any plating processes without the approval of the manufacturer.

The chain shall not be allowed to pick up dirt, etc., which would impair its free movement.

In order to attain maximum service life of hoist chain, adequate lubrication, particularly in the interlink contact areas, is necessary.

10.3 Inspection

The procedures to be followed by the operator for the inspection, at intervals, of fine tolerance hoist chain in service shall be in accordance with the hoist manufacturer's instructions, covering inspection, discard criteria and records.

NOTE For further general guidance on chain inspection procedures, see ISO 7592:1983 [1].

Annex A
(normative)

Bases for the calculation of mechanical properties and tolerances on dimensions

A.1 Nominal size

— ± 4 % of the nominal size of chain for nominal sizes less than 18 mm;

— ± 5 % of the nominal size of chain for nominal sizes of 18 mm and over, values being rounded to 0,1 mm.

A.2 Nominal pitch, multiple pitch length and width

The dimensions in Table 1 are based on the following relations:

— nominal pitch, p_n, based upon 3 d_n and with a maximum nominal value of 3,2 d_n;

— minimum inside width, W_4 = 1,2 d_n, over the weld;

— maximum outside width, W_3 = 3,4 d_n, over the weld;

The permissible tolerance for a pitch p_n or multiple pitch length l is based on the following tolerance formula:

$$\left(\frac{1{,}65}{n} + 0{,}33\right)\%$$

where n is the number of chain links (n = 11 is the standard gauge length).

This tolerance is usually divided into +2/3 and −1/3 for both the individual link and the standard gauge length.

The dimensions given in Table 1 are fully calculated values, rounded to the nearest 0,1 mm for values up to 100 mm, and rounded to the nearest millimetre for values greater than or equal to 100 mm.

The dimensions and tolerances for nominal sizes other than those given in Table 1 shall be calculated using the relations given in this clause.

A.3 Weld diameter

The diameter at the weld shall not exceed 1,08 d_n.

A.4 Formulae and rounding rules for calculation of WLL, MPF and BF

A.4.1 The formulae of the calculation of working load limits, such as those listed for selected nominal sizes in Table 4, are as follows:

— for mean stress of 200 N/mm^2, WLL = 0,032 035 3 d_n^2, in tonnes;

— for mean stress of 160 N/mm^2, WLL = 0,025 628 2 d_n^2, in tonnes;

— for mean stress of 100 N/mm^2, WLL = 0,016 017 7 d_n^2, in tonnes.

The values given in Table 4 are from the R 40 series of preferred numbers and represent the nearest lower R 40 value relative to the full calculated value of WLL.

A.4.2 The formula for the calculation of manufacturing proof force, as listed for selected nominal sizes in Table 5, is MPF = 0,785 398 2 d_n^2, expressed in kilonewtons.

The convention used is round to 0,1 kN for values up to 100 kN, and to 1 kN for values of from 100 kN to 1 000 kN.

A.4.3 Similarly, the formula for breaking force is BF_{min} = 1,256 637 1 d_n^2, in kilonewtons, using the same rounding convention as that of A.4.2.

Annex B
(normative)

Selection criteria for chain for power-driven hoists (types T, DAT and DT)

B.1 General

The selection of nominal chain size shall be determined by the geometry and dynamics of the drive system, the working capacity of the hoist, the chain type, as well as by several coefficients: some of which are calculated, and others of which are experimentally determined and specific to the hoist in question.

The following requirements are determined by the interaction between the hoist chain and its chain drive system, as well as by the loading and type of the hoist chain.

The minimum nominal size of the hoist chain to be selected is a function of the factors given in B.4.

The dynamic load limit, F_{lim}, comprises all dynamic additional stresses of the chain in hoist operation. F_{lim} shall not be exceeded in any lifting situation.

NOTE This calculation does not ensure that the chain selected will perform safely in the presence of another factor not taken into account in the calculation and which could adversely affect the performance. It remains the responsibility of the hoist manufacturer or assembler to modify the design of the hoist or chain system if the manufacturer or assembler has knowledge of any documented aspect of the design of the hoist, or any other factor not specifically taken into account in the considerations listed in clause B.4, indicating that a mean stress level lower than that given in Table B.1 ought to be maintained at the maximum permitted chain force F_{cf}.

B.2 Basis of mechanical properties, load-bearing capacity and ISO group classification

The basis for the calculation of the mechanical properties, load bearing capacity and ISO group classification of hoist chain according to this International Standard is given in Table B.1.

B.3 Operating conditions for power-driven hoists

The chain hoist should be classified into groups by mechanism, according to the prevailing operating conditions, taking into account the load spectrum and operating time in accordance with ISO 4301-1, and with co-ordination between hoist manufacturer and user.

B.4 Determination of nominal size of chain

B.4.1 Variables influencing minimum diameter

The minimum diameter of the chain depends on the following influencing variables:

a) operating conditions;

b) type of chain;

c) number of pockets in the driven chain wheel;

d) chain speed;

e) estimated nominal size d'_n;

f) impact factor;

g) factor for cyclic stress amplitude according to the type of chain;

h) polygonal geometry of the driven pocket wheels.

B.4.2 Diameter of chain resulting from dynamic loading

B.4.2.1 Diameter of d_1 resulting from load and running condition

The diameter of d_1 resulting from load and running condition (see Tables B.1 to B.9) is as follows.

NOTE Tables B.2 to B.7 contain rounded values; the exact values can be calculated using the formula given with each Table.

a) Calculation:

$$d_1 \geqslant c_1 \sqrt{\left(1 + 0{,}015 \times \frac{c_3 \times c_4}{c_2}\right) \times c_7 \times F}$$

NOTE $\left(1 + 0{,}015 \times \frac{c_3 \times c_4}{c_2}\right) \times c_7 \geqslant c_6$

where

- d_1 is the theoretical diameter of the chain, in millimetres, resulting from running conditions;
- F is the chain force in Newtons resulting from the working load;
- c_1 is the factor for type of chain and mechanism group (see ISO 4301-1);
- c_2 is the factor for number of pockets in the driven chain wheel;
- c_3 is the factor for chain speed;
- c_4 is the factor for estimated nominal size of chain d'_n;
- c_6 is the factor for cyclic stress amplitude according to grade of chain;
- c_7 is the magnification factor resulting from polygonal geometry of the driven pocket wheel.

Table B.1 — Chain properties related to ISO group classification of the mechanism

Mechanism group (ISO 4301-1)		M2		M3		M4		M5		M6		M7		M8	
Chain type		T DAT	DT	T DAT	DT	T DAT	DT	T DAT	DT	T DAT	DT	T DAT	DT	T DAT	DT
Chain stress															
Mean stress (σ_b) at minimum breaking force (BF_{min})	N/mm^2	800		800		800		800		800		800		800	
Mean stress at manufacturing proof force (MPF)	N/mm^2	500		500		500		500		500		500		500	
Mean stress (σ_{lim}) at dynamic load limit (F_{lim})	N/mm^2	225	200	200		180		160		140		125		112	
Mean stress (σ_{cf}) at maximum permitted chain force F_{cf}	N/mm^2	160	100	160	100	140	90	125	80	112	70	100	63	90	56

NOTE The stresses quoted in this table are obtained by dividing the force by the total cross-section of both sides of the link, i.e. they are mean stresses. The stress is in fact not uniform and particularly at the extrados at the crown the maximum fibre stress is considerably greater.

Table B.2 — Factor c_1

Mechanism group (ISO 4301-1)	**Type of chain** T / DAT — **Factor c_1**	**Type of chain** DT — **Factor c_1**
M2	0,053	0,056
M3	0,056	0,056
M4	0,060	0,060
M5	0,063	0,063
M6	0,068	0,068
M7	0,072	0,072
M8	0,076	0,076

$$c_1 = \sqrt{\frac{2}{\sigma_{lim} \pi}}$$

Table B.3 — Factor c_2

No of pockets Z	4	5	6	7	8	9	⩾10
Factor c_2	1,5	2,5	3,5	5	6,5	8	10

$$c_2 = \frac{Z^2}{10}$$

Table B.4 — Factor c_3

Chain speed v max.	m/min	6	8	10	12,5	16	20	25	31,5	40	50	63
Factor c_3		1	2	3	4	7	11	17	28	44	70	110

$$c_3 = \left(\frac{v}{60}\right)^2 100$$

Table B.5 — Factor c_4

d'_n mm	4	5	6	7	8	9	10	11	12	13	14	16	18	20	22
Factor c_4	5,6	4,5	3,7	3,2	2,8	2,5	2,2	2	1,9	1,7	1,6	1,4	1,2	1,1	1

$$c_4 = \frac{\pi^2 100}{4,5\, d'_n g}$$

Table B.6 — Factor c_6

Chain type		Factor c_6
T	DAT	1,25
DT		2

$$c_6 = \frac{\sigma_{lim} \times S_1}{\sigma_b}$$

Table B.7 — Factor c_7

No of pockets Z	4	5	6	7	8	9	10	11	12	⩾13
Factor c_7	1,4	1,25	1,15	1,11	1,08	1,06	1,05	1,04	1,03	1

$$c_7 = \frac{1}{\cos\left(\frac{180°}{Z}\right)}$$

b) Verification of d_1 by type testing.

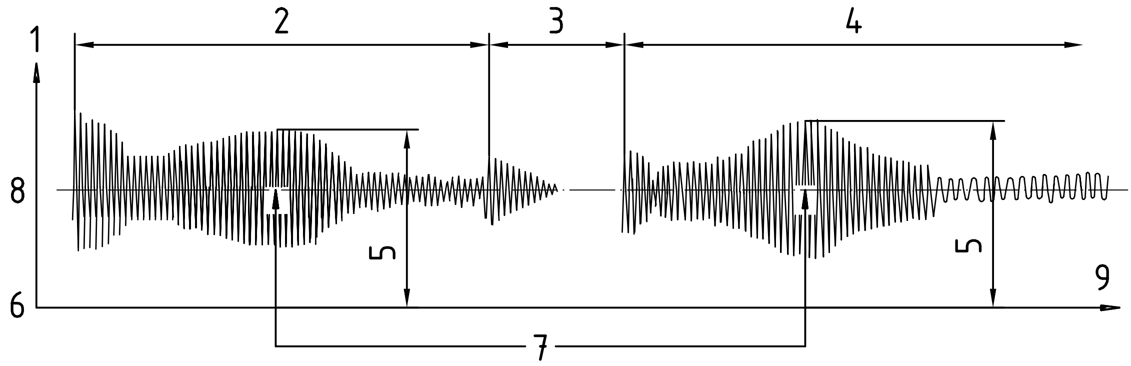
The tabled values c_2, c_3, c_4 and c_7 are calculated values for the determination of the dynamic hoist chain force, F_{dyn}, resulting from the chain running over the pocket wheel of a particular hoist. F_{dyn} is the maximum dynamic resonance value. The actual dynamic chain forces shall be measured using an appropriate load cell and recording instrument in the chain fall on the basis of the operating conditions, with the hoist suspended from a rigid mounting and including

— the working load,

— maximum lifting/lowering speed,

— reeving, and

— lifting and lowering of the load sufficient to include the first resonance (see Figure B.1).



Key

1 Force
2 Up
3 Stop
4 Down
5 First resonance force value
6 Grounded load
7 First resonance
8 Working load
9 Time

Figure B.1 — Lifting/lowering load cycle

The diameter d_1 is determined by the following equation when including the maximum dynamic resonance value F_{dyn} obtained in the type test.

$$d_1 \geqslant c_1 \times \sqrt{F_{dyn} \times c_7}$$

where F_{dyn} is the greater value derived from either

a) the maximum dynamic value obtained in the type test by measurement in the chain fall, or

b) the value derived from the formula $F_{dyn} \times c_7 \geqslant c_6 \times F$.

B.4.2.2 Diameter d_2 resulting from chain impact condition

a) Calculation.

The impact loading occurring can be higher than the forces when the chain is running, as taken into account in A.4.1. In this case, the diameter must also be determined in accordance with the following formula:

$$d_2 \geqslant c_1 \times \sqrt{c_5 \times F}$$

NOTE $c_5 \geqslant c_6$

where

d_2 is the theoretical diameter of the chain in mm resulting from impact loading

c_5 is the impact factor of the lifting equipment.

The values according to Table B.8 are guide values for lifting the load with a slack chain, without taking a sliding clutch into account.

Table B.8 — Factor c_5

Chain speed v max.	m/min	6	8	10	12,5	16	20	25	31,5	40	50	63
Factor c_5		1,25	1,4	1,8	2	2,25	2,8	2,5	2,8	3,15	3,55	4

b) Verification of d_2 by type testing.

The actual values of c_5 shall be measured using an appropriate load cell and recording instrument on the equipment, under operating conditions with rigid suspension at load and performance of a complete load cycle, for example:

— lifting with slack chain;

— lifting from suspended position;

— lifting stop;

— lowering from suspended position;

— lowering stop with suspended load.

In the case of equipment with slipping clutch, the measurement of c_5 shall be carried out with the operating slipping force specified by the manufacturer.

The maximum type test impact value c_5 obtained in this manner shall be used to determine diameter d_2 using the formulae in B.4.2.2 a), provided it exceeds the quoted c_6 value.

B.4.3 Required nominal size of chain

The greater diameter of d_1 or d_2 shall be the minimum size d_{min}.

A selection of nominal sizes is given in Table 1. The nominal size d_n shall not be smaller than d_{min}.

B.5 Verification of chain safety

The static coefficient of performance Z_{ps}:

$$Z_{ps} = \frac{{d_n}^2 \times \pi \times \sigma_b}{2 \times F} \geqslant 0,97 S_1$$

The dynamic coefficient of performance Z_{pd}:

$$Z_{pd} = \frac{{d_n}^2 \times \pi \times \sigma_b}{2 \times F^*} \geqslant 0,97 S_2$$

Where F^* is the greater of the following three values:

$$F^* = \left[1 + 0,015 \times \frac{c_3 \times c_4}{c_2} \right] \times c_7 \times F$$

$F^* = F_{dyn} \times c_7$
$F^* = F \times c_5$ } from measurements

d_n = Selected nominal chain size

Table B.9 gives the values of S_1, for the calculation of the maximum permitted chain force, and of S_2, the dynamic capacity load, for the mechanism groups given in Table B.1.

Table B.9 — Working and dynamic coefficients

Chain types		**Mechanism group** (ISO 4301-1)													
		M2		M3		M4		M5		M6		M7		M8	
		Working and dynamic coefficients													
		S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
T	DAT	5	3,6	5	4	5,6	4,5	6,3	5	7,1	5,6	8	6,3	9	7,1
DT		8	4	8	4	9	4,5	10	5	11,1	5,6	12,5	6,3	14	7,1
$S_1 = \frac{\sigma_b}{\sigma_{cf}}$ $S_2 = \frac{\sigma_b}{\sigma_{lim}}$															

Annex C
(informative)

Approximate mass of Grade T hoist chain

See Table C.1.

Table C.1 — Approximate mass of Grade T hoist chain

Nominal size d_n mm	**Mass** kg/m ≈
4	0,35
5	0,54
6	0,8
7	1,1
8	1,4
9	1,8
10	2,2
11	2,7
12	3,1
13	3,7
14	4,3
16	5,6
18	7
20	8,7
22	10,5

Bibliography

[1] ISO 7592:1983, *Calibrated round steel link lifting chains — Guidelines to proper use and maintenance*

[2] FEM 9.671[3], Section IX, *Serial hoists — Chain grades, criteria for selection requirements*

3) Fédération Européenne de la Manutention

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