Spring Steel
Shock Absorber Valve Steel

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BÖHLER UDDEHOLM
precision *strip*

BÖHLER-UDDEHOLM Precision Strip AB is one of the world's leading manufacturers of high quality strip steel. More than a century's experience of cold rolling has given us a unique competence in precision strip steel production. We are specialized in advanced combinations of properties and close tolerances.

Quality, reliability and service are the keynotes of our operations. Our extensive experience and know-how makes it possible for us to supply a comprehensive array of technical- and customer services. BÖHLER-UDDEHOLM Precision Strip AB is continuously developing new materials and products in close co-operation with the customers involving product engineers and designers in a variety of fields. In addition to spring steel and shock absorber valve steel our product range includes steel for saws, flapper valves, razor blades, scalpels, printing doctor blades and coater blades and many other precision strip steel applications in accordance with our customers' requirements.

BÖHLER-UDDEHOLM Precision Strip AB is represented worldwide. Since 1992 the company is a wholly owned subsidiary of Böhler-Uddeholm AG. Apart from our direct sales we are represented by Böhler-Uddeholm subsidiaries globally. We export about 90% of our production and work closely with our subsidiaries to ensure that we fulfil our customers' desires.

Management Systems

CERTIFIED QUALITY MANAGEMENT SYSTEM ISO/TS 16949:2002

DNV

DNV

SWEDAC ACKREDITERING
1053
EN 45012/EMS

SS-EN ISO 9001
SS-EN ISO 14001

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List of contents:

At the leading edge

Spring steel

Hardened and tempered spring steel is a material with tremendous possibilities and is uniquely suitable for many advanced applications. Where requirements as material strength, resistance to wear and fatigue strength are particularly demanding, hardened and tempered strip is the obvious choice. Other properties such as surface smoothness, edge shape, flatness and straightness also meet demanding specifications as well as the very close tolerances.

Spring steel allows rational use and cost-effective production in which the material can be blanked, formed and welded. Spring steel is an alternative to piece-hardened parts that is well worth considering.

Applications:

- Springs
- Diaphragms
- Wear parts
- Scrapers
- Shims
- Washers
- Foils
- Lapping carriers
- Food processing knives
- Sealing bands
- Saws
- Industrial blades
- Measuring tapes
- Accordion reeds
- Wafer gang saws
- Textile machine parts
- Knives

Typical specification

Steel grade	Chemical composition (% nominal)						
	C	Si	Mn	P max	S max	Cr	Mo
UHB 20C	1.00	0.30	0.45	0.015	0.006		
UHB Stainless 716	0,38	0.45	0.55	0.025	0.015	13.5	1.00

Mechanical properties
Hardened and tempered
Tensile strength:
UHB 20C, see page 10
UHB Stainless 716,
1810 ± 80 N/mm^2

Surface
White, smooth or very smooth surface

Edges
Deburred edges or sheared edges

Width tolerances
Tolerance B1 (see table)

Thickness tolerance
Tolerance T0–T1 (see table)

Flatness
Tolerance class P1–P2

Straightness
Tolerance class R2

Form of supply
Coils

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Shock absorber valve steel

The shock absorber steel from BÖHLER-UDDEHOLM Precision Strip has been developed in close co-operation with leading shock absorber manufacturers to meet the highest demands of modern automotive technology.

The steel is characterized by:

- Excellent surface finish
- Low content of undesirable constituents, no harmful inclusions
- High fatigue strength
- Accurate flatness and straightness
- Good blankability
- Uniform quality to ensure good results in shock absorber valve manufacturing

Standard specification

Steel grade	Chemical composition (% nominal)						
	C	Si	Mn	P max	S max	Cr	Mo
UHB 20C	1.00	0.30	0.45	0.015	0.006		
UHB Stainless 716	0,38	0.45	0.55	0.025	0.015	13.5	1.00

Mechanical properties
Hardened and tempered
Tensile strength:
UHB 20C, see page 10
UHB Stainless 716,
1810 ± 80 N/mm^2

Surface
White, very smooth surface

Edges
Deburred edges

Width tolerances
Tolerance B1 (see table)

Thickness tolerance
Tolerance T1–T3 (see table)

Flatness
Tolerance class P2

Straightness
Tolerance class R2

Form of supply
Coils

Steel grades for springs and shock absorber valves

Each strip steel application (operating environment and load characteristics) must be considered carefully before the choice of a suitable steel grade is made. The demands on wear resistance, corrosion resistance and tensile strength are often decisive when selecting the steel grade.

UHB 15

A grade especially designed for narrow band saw blades. Good toughness and high fatigue strength.

UHB 15LM

A grade primarily suitable for springs, knives and saws. Best combination of flexibility and toughness in thicknesses exceeding 1 mm or tensile strength less than 1800 N/mm^2.

ANKAR 2

A grade particulary used for heavy duty springs. Good toughness and high fatigue life. Good resistance to wear and heat.

UHB 20C

A multi-purpose 1% carbon steel with high tensile strength. It is often the standard choice for the medium and thinner range of various components – e.g. springs, knives and valves. It is hardened and tempered to a fine martensitic structure providing the highest fatigue strength among all unalloyed steels.

UHB 20C15

A grade with excellent wear resistance and high fatigue life. Originally designed for ball-bearing rings, -balls and -rolls. Used for knives, textile machine parts including latch needles and washers.

AEB-L

This stainless grade – "the edge steel" – was originally developed for the production of razor blades but is also used for scalpel blades and knives. Like UHB Stainless 716 and 731 AEB-L has 13% chromium. The right choice for high sharpness, wear resistance and corrosion resistance.

UHB 15N20

A Ni-alloyed 0.75% carbon steel which is ideal for the heavier size range. Typical applications are saw blades, valves and springs. It has 2% nickel, which assures a homogenous structure of fine-grained martensite through the complete cross section.

UHB Stainless 716

A multi-purpose stainless steel grade designed for the medium and thinner range of various components where toughness and impact strength are essential.

UHB Stainless 716 is also used at elevated working temperatures and/or in corrosive atmosphere. The 13% chromium steel is delivered in the hardened and tempered condition and has been proven to offer superior fatigue properties.

UHB Stainless 731

This grade is used for heavier sizes. It is a 13% chromium steel with a reduced carbon content. This simplifies the blanking of heavier parts. UHB Stainless 731 offers toughness, wear resistance and fatigue strength.

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Steel grade selection guide

Working condition		Carbon steels						Martensitic stainless steels		
		UHB 15	UHB 15LM	ANKAR 2	UHB 15N20	UHB 20C	UHB 20C15	Stainless 731	Stainless 716	AEB-L
Size	max 1 mm	■				■	■		■	■
	over 1 mm		■	■	■			■		*)
Fatigue load	moderate ↓ high	■	■	■	■	■	■	■	■	■
Wear	moderate ↓ high	■	■	■	■	■	■	■	■	■
Risk for corrosion	low ↓ high	■	■	■	■	■	■	■	■	■
Demand on flatness after blanking	moderate ↓ high	■ **)	■ **)	■ **)	■	■	■	■ **)	■ **)	■ **)
Operation temperature	max 200°C	■	■	■	■	■	■	■	■	■
	max 400°C							■	■	■

*) Available in unhardened condition
**) Photo chemical machining or laser cutting to be considered instead of blanking

■ recommended
□ not recommended

At the leading edge

Chemical composition

Steel Grade	Chemical composition [% nominal]							
	C	Si	Mn	P max	S max	Cr	Ni	Mo
UHB 15	0.71	0.30	0.50	0.018	0.008			
UHB 15LM	0.75	0.20	0.73	0.018	0.008			
ANKAR 2	0.67	1.30	0.50	0.020	0.010	0.20		
UHB 15N20	0.75	0.30	0.40	0.018	0.005	0.11	2.00	
UHB 20C	1.00	0.30	0.45	0.015	0.006	0.15		
UHB 20C15	1.00	0.30	0.35	0.020	0.001	1.45		
Stainless 731	0.21	0.40	0.45	0.025	0.015	13.2	0.40	
Stainless 716	0.38	0.45	0.55	0.025	0.015	13.5		1.00
AEB-L	0.67	0.40	0.60	0.025	0.006	13.0		

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Specification

Typical product characteristics

Steel grade	UHB 15	UHB 15LM	ANKAR 2	UHB 15N20	UHB 20C	UHB 20C15	UHB 731	UHB 716	UHB AEB-L
Width range [mm]	max 400	max 400	max 200	max 400	max 320	max 320	max 320	max 320	max 320
Thickness range [mm]	≤ 1	> 1 – 3	> 1 – 2	> 1 – 2	≤ 1	≤ 1.2	> 1 – 1.5	≤ 1	≤ 0.5
Surface finish ≤ 0.60 mm (.0236")	white extra smooth						for details see **remarks** below		
> 0.60 – 1.00 mm (> .0236"– .0394")	white very smooth								
> 1.00 – 1.50 mm (> .0394"– .0590")	white smooth								
Edges	slitted, deburred or machined								
Width tolerance	B1 – B4 (see table – **page 14**)								
Thickness tolerance	T1 – T4 (see table – **page 15**)								
Flatness group	P1 – P3 (see table – **page 16**)								
Straightness group	R1 – R4 (see table – **page 16**)								
Form of supply	coils								
Tensile strength MPa [N/mm²]	1450 +/- 80	1450 +/- 80	1560 +/- 80	1520 +/- 80	see page 10	1560 – 1860 +/- 80	1670 +/- 80	1810 +/- 80	2160 +/- 80

Remarks:

- Size conversion from metric to inch: divide metric [mm] by 25.4.
- Tensile strength conversion from MPa to psi [pound per square inch]: multiply MPa with 145.
- Fixed lengths can be supplied upon request.

Remarks to surface finish:

Thickness	Designation	Ra	Rz	Cut-off
≤ 0.60 mm ≤ .0236"	white extra smooth ("8"-type)	max. 0.125 µm (5 µinch)	max. 1.00 µm (40 µinch)	0.25 mm (.01 inch)
> 0.60 – 1.00 mm (> .0236"– .0394")	white very smooth ("7"-type)	max. 0.25 µm (10 µinch)	max. 2.20 µm (88 µinch)	0.80 mm (.03 inch)
> 1.00 – 1.50 mm (> .0394"– .0590")	white smooth ("6"-type)	max. 0.50 µm (20 µinch)	max. 5.00 µm (200 µinch)	0.80 mm (.03 inch)

Mechanical properties

Tensile strength, UHB 20C

Thickness [mm]	Tensile strength [MPa], [N/mm2]	Hardness [HV]
0.000–0.124	2110 ±80	~ 620
0.125–0.174	2060 ±80	~ 605
0.175–0.224	2010 ±80	~ 590
0.225–0.274	1960 ±80	~ 580
0.275–0.374	1910 ±80	~ 565
0.375–0.424	1860 ±80	~ 555
0.425–0.474	1810 ±80	~ 540
0.475–0.624	1770 ±80	~ 525
0.625–0.824	1720 ±80	~ 515
0.825–1.149	1670 ±80	~ 500
1.150–1.499	1620 ±80	~ 490
1.500–1.999	1570 ±80	~ 475
2.000–2.999	1520 ±80	~ 460

Tensile strength in pounds per sq. inch:
multiply MPa with 145

Ultimate tensile strength (UTS), annealed condition

UHB steel grade	UTS [MPa], [N/mm2]
15	~ 570
15LM	~ 590
Ankar 2	~ 690
15N20	~ 620
20C	~ 580
20C15	~ 630
SS731	~ 590
SS716	~ 680
AEB-L	~ 730

Hardness after tempering

Hardness values for hardened carbon and stainless steel grades

UHB grade	Hardening temperature [°C]	Hardness after tempering 30 minutes at											
		100°C		200°C		300°C		400°C		500°C		600°C	
		[HV]	[HRC]	[HV]	[HRC]	[HV]	[HRC]	[HV]	[HRC]	[HV]	[HRC]	[HV]	[HRC]
15	800	870	66	740	62	600	55	460	46	360	37	270	26
15LM	800	870	66	740	62	600	55	460	46	360	37	270	26
Ankar 2	880	870	66	740	62	690	60	640	57	470	47	350	36
15N20	800	820	65	700	60	560	53	470	47	390	40	320	32
20C	810	920	67	765	63	640	57	500	49	400	41	290	29
20C15	840	870	66	770	63	650	58	560	53	450	45	340	35
SS731	1025	640	57	570	53	500	49	510	50				
SS716	1025	690	60	620	56	550	52	550	52				
AEB-L	1025	770	63	700	60	630	57	630	57				
	1080*	810	65	740	62	660	58	670	59				

* After deep freezing at -70°C.

(All HV and HRC values given are approximate.)

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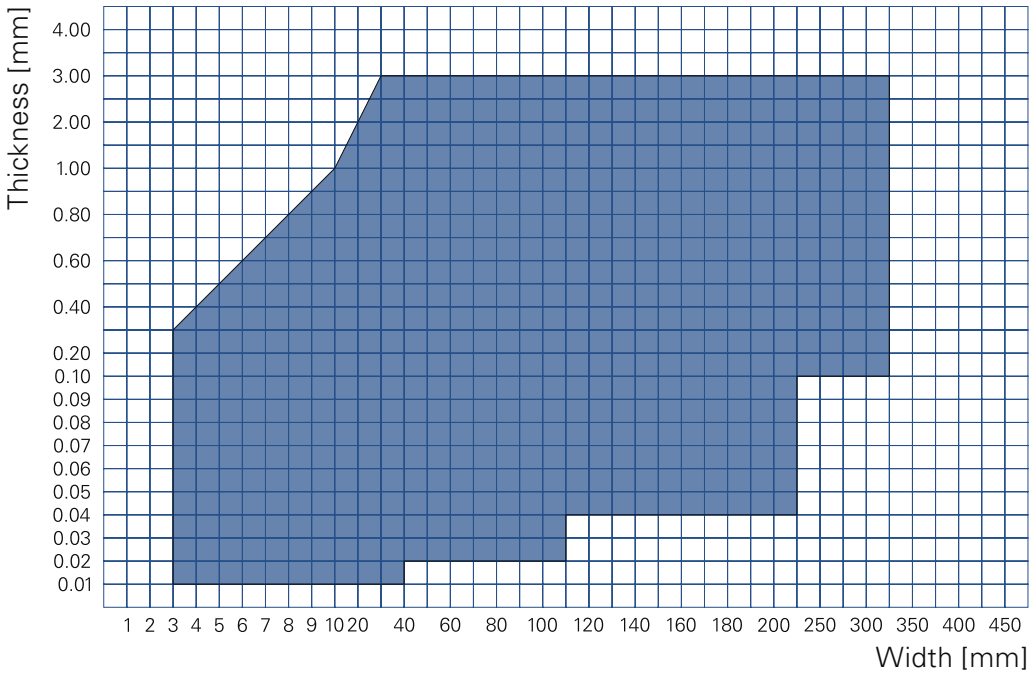
Sizes

Size range chart



Coil sizes

We normally supply the coils on 400 or 500 mm inner diameter. The table shows the coil-weight in kgs per mm strip width for different outside diameters (OD). From this information you can calculate the coil-weight by multiplying kg/mm and strip width.

Example: ID = 400 m, OD = 800 mm
The table gives 2.94 kg per mm strip width.
A 120 mm wide strip will have an approx weight of: 2.94 x 120 = 353 kg

Coil weight in kg/mm strip width

OD [mm]	ID = 300 mm [kg/mm]	ID = 350 mm [kg/mm]	Id = 400 mm [kg/mm]	ID = 500 mm [kg/mm]
350	0.20			
400	0.43	0.23		
450	0.69	0.49	0.26	
500	0.98	0.78	0.55	
550	1.30	1.10	0.87	0.32
600	1.65	1.45	1.22	0.67
650	2.04	1.84	1.61	1.06
700	2.45	2.25	2.02	1.47
750	2.89	2.69	2.46	1.91
800	3.37	3.17	2.94	2.39
850	3.87	3.67	3.44	2.89
900	4.41	4.21	3.98	3.43
950	4.97	4.78	4.55	4.00
1000	5.57	5.37	5.14	4.59
1050	6.20	6.00	5.77	5.22
1100	6.86	6.66	6.43	5.88
1150	7.55	7.35	7.12	6.57
1200	8.27	8.07	7.84	7.29
1250	9.02	8.82	8.59	8.04
1300	9.80	9.60	9.37	8.82
1350	10.61	10.41	10.18	9.63
1400	11.45	11.25	11.02	10.47
1450	12.32	12.12	11.89	11.34
1500	13.23	13.03	12.80	12.25

Surface

Our different surface finishes are designated by a figure-code.

The first figure indicates the surface appearance and the second figure indicates the surface smoothness:

Surface appearance designations

Code	Designation	Definition
0	Unspecified	An oxidized surface, not complying with special appearance demands.
1	Grey	A slightly oxidized surface, not complying with special appearance demands.
2	Dull	Dull surface, complying with demands on uniform surface appearance.
3	Bright	Bright surface complying with requirements of uniform surface appearance.
4	Very bright	Very bright surface, complying with stringent requirements of uniform surface appearance.
5	Extra bright	Mirror-bright surface, complying with very stringent requirements of uniform surface appearance.
6	Yellow	Yellow, oxidized surface complying with demands on uniform color.
7	Blue	Blue, oxidized surface complying with demands on uniform color.
8	White	Surface free from oxide discoloration complying with demands on uniform color.
9	Special	As per customer's special requirements.

Surface smoothness designations

Code	Designation	Class limit Ra [µm] *)	Mean value Ra [µm]	Cut-off [mm]
1	unspecified	–	–	–
2	"2" surface	3.2 – 8	5.0	0.8
3	"3" surface	1.6 – 4	2.5	0.8
4	"4" surface	0.8 – 2	1.25	0.8
5	"5" surface (smooth)	0.4 – 1	0.63	0.8
6	"6" surface (smooth)	0.2 – 0.5	0.32	0.8
7	"7" surface (very smooth)	0.1 – 0.25	0.16	0.8
8	"8" surface (extra smooth)	0.05 – 0.125	0.08	0.25
9	special	As per customer's special requirements.		

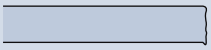
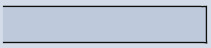
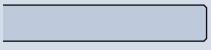
*) Upper value of class limit equals guaranteed value.

Edges

Our different edge profiles are designated by a figure code.

The first figure indicates the profile. The second figure indicates the finish of the edge surface:

Edge profile designations

Code	Designation		Definition
0	Mill edges		Untreated edges of rolled strip, generally showing a somewhat uneven profile
1	Sheared		Edge profile used when no particular demands have been specified
2	Deburred		Edges from which burrs have been removed
3	Square		Right angled deburred edges
4	Rounded corners		Treated edges with rounded corners
5	Round		Round, treated edges
6	Right angled, sharp		Right angled edge with sharp corners
7	Right angled, blunt		Right angled edge with slightly bevelled or rounded corners
8	Bevelled		Different bevelled edges as per descriptions available on request
9	Special		As per customer's special requirement

Edge surface finish designations

Code	Designation	Definition
1	Raw	Edge surface untreated
2	Smooth	Smooth edge surface
4	Very smooth	Very smooth edge surface
5	Extra smooth	Edge surface completely free from defects visible to the naked eye
9	Special	As per customer's special requirement

Tolerances

Width tolerances, metric

Nominal strip thickness [mm]	Nominal strip width [mm]	Tolerance [±mm]				
		B0	B1	B2	B3	B4
–(0.25)	–(20)	0.10	0.07	0.05	0.03	0.02
	20–(50)	0.15	0.10	0.07	0.05	0.04
	50–(125)	0.20	0.15	0.11	0.07	0.05
	125–(250)	0.30	0.20	0.15	0.10	0.07
	250–(400)	0.45	0.30	0.20	0.15	0.10
	400–(600)	0.60	0.40	0.30	0.20	–
0.25–(0.50)	–(20)	0.15	0.10	0.07	0.05	0.03
	20–(50)	0.20	0.15	0.11	0.07	0.05
	50–(125)	0.30	0.20	0.15	0.10	0.07
	125–(250)	0.35	0.25	0.20	0.15	0.10
	250–(400)	0.50	0.35	0.30	0.20	0.15
	400–(600)	0.70	0.50	0.35	0.25	–
0.50–(1.00)	–(20)	0.20	0.15	0.11	0.07	0.05
	20–(50)	0.30	0.20	0.15	0.10	0.07
	50–(125)	0.35	0.25	0.20	0.15	0.10
	125–(250)	0.45	0.30	0.25	0.15	0.10
	250–(400)	0.60	0.40	0.30	0.20	0.15
	400–(600)	0.85	0.60	0.40	0.30	–
1.00–(1.60)	–(20)	0.30	0.20	0.15	0.10	0.07
	20–(50)	0.40	0.25	0.20	0.15	0.10
	50–(125)	0.45	0.30	0.25	0.15	0.10
	125–(250)	0.50	0.35	0.25	0.20	0.15
	250–(400)	0.65	0.45	0.35	0.25	0.20
	400–(600)	1.00	0.70	0.50	0.35	–
1.60–(2.00)	–(20)	0.40	0.25	0.20	0.15	0.10
	20–(50)	0.45	0.30	0.20	0.15	0.10
	50–(125)	0.50	0.35	0.30	0.20	0.15
	125–(250)	0.60	0.40	0.30	0.20	0.15
	250–(400)	0.70	0.50	0.35	0.25	0.20
	400–(600)	1.00	0.70	0.50	0.35	–
2.00–(2.50)	–(20)	0.55	0.35	0.25	0.20	0.15
	20–(50)	0.55	0.35	0.25	0.20	0.15
	50–(125)	0.60	0.40	0.30	0.20	0.15
	125–(250)	0.65	0.45	0.35	0.25	0.20
	250–(400)	0.80	0.55	0.40	0.30	0.25
	400–(600)	1.15	0.80	0.60	0.40	–
2.50– 4.00	–(20)	–	–	–	–	–
	20–(50)	0.60	0.40	0.30	0.20	0.15
	50–(125)	0.65	0.45	0.30	0.20	0.15
	125–(250)	0.70	0.50	0.35	0.25	0.20
	250–(400)	0.85	0.60	0.40	0.30	0.25
	400–(600)	1.15	0.80	0.60	0.40	–

Width tolerances, inch

Nominal strip thickness [in]	Nominal strip width [in]	Tolerance [±inch]				
		B0	B1	B2	B3	B4
–(.0098)	–(.787)	.0039	.0028	.0020	.0012	.0008
	.787–(1.969)	.0059	.0039	.0028	.0020	.0016
	1.969–(4.921)	.0079	.0059	.0043	.0028	.0020
	4.921–(9.843)	.0118	.0079	.0059	.0039	.0028
	9.843–(15.748)	.0177	.0118	.0079	.0059	.0039
	15.748– 23.622	.0236	.0157	.0118	.0079	–
.0098–(.0197)	–(.787)	.0059	.0039	.0028	.0020	.0012
	.787–(1.969)	.0079	.0059	.0043	.0028	.0020
	1.969–(4.921)	.0118	.0079	.0059	.0039	.0028
	4.921–(9.843)	.0138	.0098	.0079	.0059	.0039
	9.843–(15.748)	.0197	.0138	.0118	.0079	.0059
	15.748– 23.622	.0276	.0197	.0138	.0098	–
.0197–(.0394)	–(.787)	.0079	.0059	.0043	.0028	.0020
	.787–(1.969)	.0118	.0079	.0059	.0039	.0028
	1.969–(4.921)	.0138	.0098	.0079	.0059	.0039
	4.921–(9.843)	.0177	.0118	.0098	.0059	.0039
	9.843–(15.748)	.0236	.0157	.0118	.0079	.0059
	15.748– 23.622	.0335	.0236	.0157	.0118	–
.0394–(.0630)	–(.787)	.0118	.0079	.0059	.0039	.0028
	.787–(1.969)	.0157	.0098	.0079	.0059	.0039
	1.969–(4.921)	.0177	.0118	.0098	.0059	.0039
	4.921–(9.843)	.0197	.0138	.0098	.0079	.0059
	9.843–(15.748)	.0256	.0177	.0138	.0098	.0079
	15.748– 23.622	.0394	.0276	.0197	.0138	–
.0630–(.0787)	–(.787)	.0157	.0098	.0079	.0059	.0039
	.787–(1.969)	.0177	.0118	.0079	.0059	.0039
	1.969–(4.921)	.0197	.0138	.0118	.0079	.0059
	4.921–(9.843)	.0236	.0157	.0118	.0079	.0059
	9.843–(15.748)	.0276	.0197	.0138	.0098	.0079
	15.748– 23.622	.0394	.0276	.0197	.0138	–
.0787–(.0984)	–(.787)	.0217	.0138	.0098	.0079	.0059
	.787–(1.969)	.0217	.0138	.0098	.0079	.0059
	1.969–(4.921)	.0236	.0157	.0118	.0079	.0059
	4.921–(9.843)	.0256	.0177	.0138	.0098	.0079
	9.843–(15.748)	.0315	.0217	.0157	.0118	.0098
	15.748– 23.622	.0453	.0315	.0236	.0157	–
.0984– .1575	–(.787)	–	–	–	–	–
	.787–(1.969)	.0236	.0157	.0118	.0079	.0059
	1.969–(4.921)	.0256	.0177	.0118	.0079	.0059
	4.921–(9.843)	.0276	.0197	.0138	.0098	.0079
	9.843–(15.748)	.0335	.0236	.0157	.0118	.0098
	15.748– 23.622	.0453	.0315	.0236	.0157	–

Spring Steel
Shock Absorber Steel

Thickness tolerances, metric

Nominal strip thickness [mm]	Nominal strip width [mm]	Tolerance [±mm]					
		T0	T1	T2	T3	T4	T5
–(0.025)	–(250)	0.004	0.003	0.002	0.0015	0.001	–
	250–(400)	0.005	0.004	0.003	0.002	0.0015	–
	400– 600	–	–	–	–	–	–
0.025–(0.040)	–(250)	0.005	0.004	0.003	0.002	0.0015	0.001
	250–(400)	0.006	0.005	0.004	0.003	0.002	0.0015
	400– 600	–	–	–	–	–	–
0.040–(0.063)	–(250)	0.007	0.005	0.004	0.003	0.002	0.0015
	250–(400)	0.008	0.006	0.005	0.004	0.003	0.002
	400– 600	–	–	–	–	–	–
0.063–(0.100)	–(250)	0.009	0.006	0.005	0.004	0.003	0.002
	250–(400)	0.010	0.007	0.006	0.005	0.004	0.003
	400– 600	–	–	–	–	–	–
0.100–(0.125)	–(250)	0.010	0.007	0.005	0.004	0.003	0.002
	250–(400)	0.011	0.008	0.006	0.005	0.004	0.003
	400– 600	–	–	–	–	–	–
0.125–(0.160)	–(250)	0.012	0.009	0.006	0.005	0.004	0.003
	250–(400)	0.013	0.010	0.007	0.006	0.005	0.004
	400– 600	–	–	–	–	–	–
0.160–(0.200)	–(250)	0.014	0.010	0.007	0.005	0.004	0.003
	250–(400)	0.015	0.011	0.008	0.006	0.005	0.004
	400– 600	–	–	–	–	–	–
0.200–(0.250)	–(250)	0.016	0.011	0.008	0.006	0.004	0.003
	250–(400)	0.018	0.013	0.009	0.007	0.006	0.005
	400– 600	0.020	0.014	0.010	0.008	0.007	0.006
0.250–(0.315)	–(250)	0.018	0.013	0.009	0.007	0.005	0.004
	250–(400)	0.021	0.015	0.011	0.008	0.006	0.005
	400– 600	0.024	0.017	0.012	0.009	0.007	0.006
0.315–(0.400)	–(250)	0.021	0.015	0.011	0.008	0.006	0.004
	250–(400)	0.024	0.017	0.012	0.009	0.007	0.005
	400– 600	0.028	0.020	0.014	0.010	0.008	0.007
0.400–(0.500)	–(250)	0.024	0.017	0.012	0.009	0.006	0.004
	250–(400)	0.028	0.020	0.014	0.010	0.007	0.005
	400– 600	0.033	0.023	0.017	0.012	0.009	0.007
0.500–(0.630)	–(250)	0.028	0.020	0.014	0.010	0.007	0.005
	250–(400)	0.034	0.024	0.017	0.012	0.009	0.006
	400– 600	0.040	0.028	0.020	0.014	0.010	0.008
0.630–(0.800)	–(250)	0.033	0.023	0.017	0.012	0.008	0.006
	250–(400)	0.039	0.027	0.020	0.014	0.010	0.007
	400– 600	0.046	0.032	0.023	0.016	0.012	0.008
0.800–(1.000)	–(250)	0.038	0.027	0.019	0.013	0.009	0.007
	250–(400)	0.045	0.032	0.023	0.016	0.012	0.008
	400– 600	0.053	0.037	0.027	0.019	0.014	0.010
1.000–(1.250)	–(250)	0.048	0.034	0.024	0.017	0.012	0.008
	250–(400)	0.052	0.036	0.026	0.018	0.013	0.009
	400– 600	0.060	0.042	0.029	0.021	0.015	0.010
1.250–(1.600)	–(250)	0.056	0.039	0.028	0.020	0.014	0.009
	250–(400)	0.063	0.044	0.032	0.022	0.016	0.011
	400– 600	0.075	0.050	0.038	0.026	0.019	0.013
1.600–(2.000)	–(250)	0.066	0.046	0.033	0.023	0.017	0.011
	250–(400)	0.075	0.050	0.038	0.026	0.019	0.013
	400– 600	0.085	0.060	0.042	0.029	0.021	0.015
2.000–(2.500)	–(250)	0.070	0.050	0.035	0.025	0.017	0.012
	250–(400)	0.080	0.055	0.040	0.028	0.020	0.014
	400– 600	0.095	0.065	0.050	0.033	0.024	0.017
2.500–(3.150)	–(250)	0.080	0.056	0.040	0.028	0.020	0.014
	250–(400)	0.085	0.060	0.043	0.030	0.022	0.015
	400– 600	0.100	0.070	0.050	0.035	0.025	0.018
3.150– 4.000	–(250)	0.090	0.063	0.045	0.032	0.022	0.015
	250–(400)	0.095	0.065	0.050	0.034	0.024	0.017
	400– 600	0.115	0.080	0.060	0.040	0.029	0.020

Thickness tolerances, inch

Nominal strip thick-ness [in]	Nominal strip width [in]	Tolerance [±inch]					
		T0	T1	T2	T3	T4	T5
–(.00098)	–(9.8)	.00016	.00012	.00008	.00006	.00004	–
	9.8–(15.7)	.00020	.00016	.00012	.00008	.00006	–
	15.7– 23.6	–	–	–	–	–	–
.00098– (.00157)	–(9.8)	.00020	.00016	.00012	.00008	.00006	.00004
	9.8–(15.7)	.00024	.00020	.00016	.00012	.00008	.00006
	15.7– 23.6	–	–	–	–	–	–
.00157– (.00248)	–(9.8)	.00028	.00020	.00016	.00012	.00008	.00006
	9.8–(15.7)	.00031	.00024	.00020	.00016	.00012	.00008
	15.7– 23.6	–	–	–	–	–	–
.00248– (.00394)	–(9.8)	.00035	.00024	.00020	.00016	.00012	.00008
	9.8–(15.7)	.00039	.00028	.00024	.00020	.00016	.00012
	15.7– 23.6	–	–	–	–	–	–
.00394– (.00492)	–(9.8)	.00039	.00028	.00020	.00016	.00012	.00008
	9.8–(15.7)	.00043	.00031	.00024	.00020	.00016	.00012
	15.7– 23.6	–	–	–	–	–	–
.00492– (.00630)	–(9.8)	.00047	.00035	.00024	.00020	.00016	.00012
	9.8–(15.7)	.00051	.00039	.00028	.00024	.00020	.00016
	15.7– 23.6	–	–	–	–	–	–
.00630– (.00787)	–(9.8)	.00055	.00039	.00028	.00020	.00016	.00012
	9.8–(15.7)	.00059	.00043	.00031	.00024	.00020	.00016
	15.7– 23.6	–	–	–	–	–	–
.00787– (.00984)	–(9.8)	.00063	.00043	.00031	.00024	.00016	.00012
	9.8–(15.7)	.00071	.00051	.00035	.00028	.00024	.00020
	15.7– 23.6	.00079	.00055	.00039	.00031	.00028	.00024
.00984– (.01240)	–(9.8)	.00071	.00051	.00035	.00028	.00020	.00016
	9.8–(15.7)	.00083	.00059	.00043	.00031	.00024	.00020
	15.7– 23.6	.00094	.00067	.00047	.00035	.00028	.00024
.01240– (.01575)	–(9.8)	.00083	.00059	.00043	.00031	.00024	.00016
	9.8–(15.7)	.00094	.00067	.00047	.00035	.00028	.00020
	15.7– 23.6	.00110	.00079	.00055	.00039	.00031	.00028
.01575– (.01969)	–(9.8)	.00094	.00067	.00047	.00035	.00024	.00016
	9.8–(15.7)	.00110	.00079	.00055	.00039	.00028	.00020
	15.7– 23.6	.00130	.00091	.00067	.00047	.00035	.00028
.01969– (.02480)	–(9.8)	.00110	.00079	.00055	.00039	.00028	.00020
	9.8–(15.7)	.00134	.00094	.00067	.00047	.00035	.00024
	15.7– 23.6	.00157	.00110	.00079	.00055	.00039	.00031
.02480– (.03150)	–(9.8)	.00130	.00091	.00067	.00047	.00031	.00024
	9.8–(15.7)	.00154	.00106	.00079	.00055	.00039	.00028
	15.7– 23.6	.00181	.00126	.00091	.00063	.00047	.00031
.03150– (.03937)	–(9.8)	.00150	.00106	.00075	.00051	.00035	.00028
	9.8–(15.7)	.00177	.00126	.00091	.00063	.00047	.00031
	15.7– 23.6	.00209	.00146	.00106	.00075	.00055	.00039
.03937– (.04921)	–(9.8)	.00189	.00134	.00094	.00067	.00047	.00031
	9.8–(15.7)	.00205	.00142	.00102	.00071	.00051	.00035
	15.7– 23.6	.00236	.00165	.00114	.00083	.00059	.00039
.04921– (.06299)	–(9.8)	.00220	.00154	.00110	.00079	.00055	.00035
	9.8–(15.7)	.00248	.00173	.00126	.00087	.00063	.00043
	15.7– 23.6	.00295	.00197	.00150	.00102	.00075	.00051
.06299– (.07874)	–(9.8)	.00260	.00181	.00130	.00091	.00067	.00043
	9.8–(15.7)	.00295	.00197	.00150	.00102	.00075	.00051
	15.7– 23.6	.00335	.00236	.00165	.00114	.00083	.00059
.07874– (.09843)	–(9.8)	.00276	.00197	.00138	.00098	.00067	.00047
	9.8–(15.7)	.00315	.00217	.00157	.00110	.00079	.00055
	15.7– 23.6	.00374	.00256	.00197	.00130	.00095	.00067
.09843– (.12402)	–(9.8)	.00315	.00221	.00157	.00110	.00079	.00055
	9.8–(15.7)	.00335	.00236	.00169	.00118	.00087	.00059
	15.7– 23.6	.00394	.00276	.00197	.00138	.00098	.00071
.12402– .15748	–(9.8)	.00354	.00248	.00177	.00126	.00087	.00059
	9.8–(15.7)	.00374	.00256	.00197	.00134	.00094	.00067
	15.7– 23.6	.00453	.00315	.00236	.00157	.00114	.00079

Flatness tolerances

The unflatness **across** the strip (also called cross camber and cross bow) is expressed as a percentage of the strip width. The unflatness **along** the strip, sometimes called coil-set, is also expressed as a percentage. Unless otherwise agreed upon the measuring length = the strip width for flatness measurements along and across the strip. Influence of possible residual stresses from slitting shall be excluded.

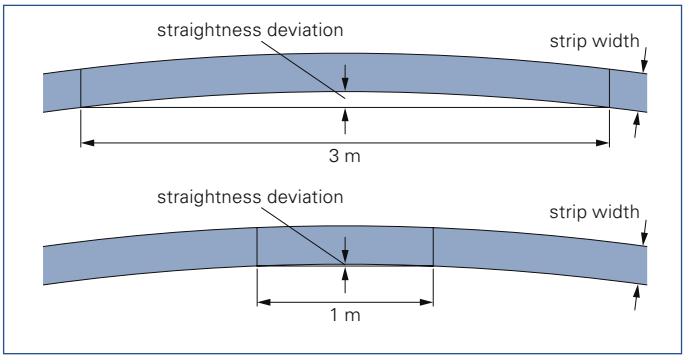
Tolerance class	Maximum permitted deviation [% of nominal strip width]
P0	Unspecified
P1	0.4
P2	0.3
P3	0.2
P4	0.1
P9	as per customer's special requirement

Straightness tolerances

Tolerance class	Strip width									
	< 8 mm		8 – (20) mm		20 – (50) mm		50 – (125) mm		125 mm	
	Measuring length									
	1 m	3 m	1 m	3 m	1 m	3 m	1 m	3 m	1 m	3 m
	Maximum allowed straightness deviation [mm]									
R1	7	63	5	45	3.5	31.5	2.5	22.5	2	18
R2	3	27	2	18	1.5	13.5	1.25	11.3	1	9
R3	2	18	1.5	13.5	1	9	0.8	7.2	0.5	4.5
R4	1.5	13.5	1	9	0.7	6.3	0.5	4.5	0.3	2.7
R9	As per customer's special requirements									

Straightness deviation is specified in millimetres and defined as lateral deviation of the edge from a straight line as shown in the graphic.

The straightness deviation is stated as edge camber (bow) and measured over a strip length of 1 or 3 metres. Straightness tolerance depends on the strip width and is given as one of five straightness classification groups (R).



Spring Steel
Shock Absorber Steel

Hardness table

The chart is primarily valid for plain carbon and low alloyed grades. However the "1 % C"-column can also be used for martensitic stainless grades. **Values are approximate**.

Vickers	Rockwell			Tensile strength (N/mm2)				
				Annealed	Cold rolled			Hardened and tempered
HV	HRB	HRC	HRN30		0.1 % C	0.5 % C	1.0 % C	
80				270				
90				300				
100				330				
110	62.0			360				
120	67.0			390	290			
130	71.0			420	330			
140	75.1			450	370			
150	78.8			480	410			
160	82.1			510	450	400		
170	85.0			540	490	450		
180	87.3			570	530	490		
190	89.6			600	580	530		
200	91.8			630	620	570	540	
210	93.7			660	660	610	580	
220	95.0			690	700	650	620	
230	96.7			720	740	700	670	
240	98.1	20.3	41.7	750	770	740	710	
250	99.5	22.2	43.4	770	820	770	750	
260		24.0	45.0	800	860	810	790	830
270		25.6	46.4	830	900	860	820	870
280		27.1	47.8	860	940	900	860	900
290		28.5	49.0			940	910	940
300		29.8	50.2			980	950	970
310		31.0	51.3			1020	990	1010
320		32.2	52.3			1060	1030	1040
330		33.3	53.6				1080	1080
340		34.4	54.4				1120	1110
350		35.5	55.4				1160	1150
360		36.6	56.4				1200	1180
370		37.7	57.4					1220
380		38.8	58.4					1250
390		39.8	59.3					1290
400		40.8	60.2					1310
410		41.8	61.1					1350
420		42.7	61.9					1380
430		43.6	62.7					1420
440		44.5	63.5					1450
450		45.3	64.3					1490
460		46.1	64.9					1520
470		46.9	65.7					1560
480		47.7	66.4					1590
490		48.4	67.1					1630
500		49.1	67.7					1670
510		49.8	68.3					1710
520		50.5	69.0					1750
530		51.1	69.5					1790
540		51.7	70.0					1810
550		52.3	70.5					1850
560		53.0	71.2					1890
570		53.6	71.7					1930
580		54.1	72.1					1960
590		54.7	72.7					2000
600		55.2	73.2					2040
610		55.7	73.7					2080
620		56.3	74.2					2120
630		56.8	74.6					2160
640		57.3	75.1					2200
650		57.8	75.5					2240
660		58.3	75.9					2280
670		58.8	76.4					2310
680		59.2	76.8					2350
690		59.7	77.2					
700		60.1	77.6					
720		61.0	78.4					
740		61.8	79.1					
760		62.5	79.7					
780		63.3	80.4					
800		64.0	81.1					
820		64.7	81.7					
840		65.3	82.2					
860		65.9	82.7					
880		66.4	83.1					
900		67.0	83.6					
920		67.5	84.0					
940		68.0	84.4					

Bending

Chemical composition, structure, hardness and thickness are all essential factors influencing the bendability of strip steel, as well as the direction of the bending.

The values given in the table below are based on a test with 90° bending in a die having an opening of 20 mm. The tested components were blanked, burrs were facing the punch.

Please observe that these values should be used for guidance only.

Material	Strip thickness [mm]	Tensile strength [N/mm²] [MPa]	Min radius at 90° bending [mm]		Spring back angle [°]
			∥ *	⊥ *	
Carbon steel: Hardened and tempered	0.2	1700	2.0	1.5	5 – 10
	0.4		3.0	2.5	10 – 20
	0.6		5.0	3.5	20
	0.2	2000	2.0	1.5	5 – 10
	0.4		4.0	3.0	10 – 20
	0.6		6.5	4.0	20
Stainless steel: Hardened and tempered	0.2	1800	0.8	0.6	5 – 10
	0.4		1.8	1.2	10
	0.6		2.8	1.7	20

Certain physical characteristics

Physical characteristics	Carbon-steels	Martensitic stainless steel
Density g/cm³	7.8	7.7
lbs/cu in	0.28	0.28
Modulus of elasticity (MPa)	205000	220000
Yield strength / ultimate tensile strength ratio (Rp0,2 / Rm)	0.9	0.8
Mean linear expansion coefficient (x10⁻⁶ °C⁻¹)		
20 – 100 °C	10.5	10.5
20 – 200 °C	11.5	11.0
20 – 300 °C	12.0	11.3
Specific heat capacity (20 °C, J/kg °C)	460	460
Thermal conductivity (20 °C, W/m °C)	49	24

Packaging

It is essential that the strip steel is packed in a satisfactory way. The mode of conveyance, the sensitivity of the strip material and the destination will influence the choice of packing.

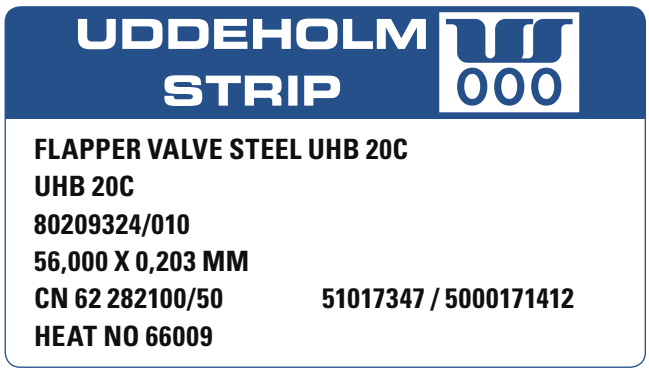
BÖHLER-UDDEHOLM Precision Strip AB can offer a wide range of packing alternatives.

Example: Wooden box, plastic bag, paper wrapped coils and center support.

Example: Disposable pallet, paper wrapped coils.

Labeling

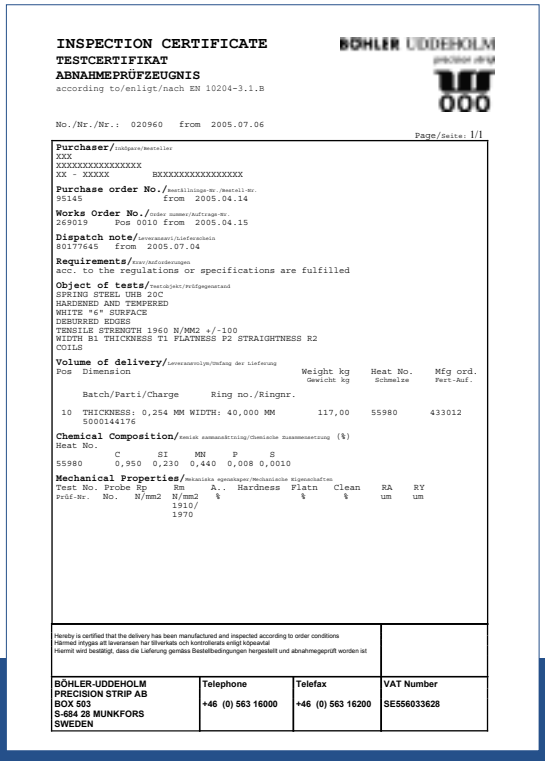
Both the packing and strip coils are equipped with labels. The labels will show steel grade, size, packing note number, order number and other information in order to ensure easy identification and traceability.



Example of coil label.

Documentation

Upon request a material certificate can be supplied. Normally the test-analysis and tensile strength are included.



INSPECTION CERTIFICATE
TESTCERTIFIKAT
ABNAHMEPRÜFZEUGNIS
according to/enligt/nach EN 10204-3.1.B

BÖHLER UDDEHOLM precision strip
000

No./Nr./Nr.: 020960 from 2005.07.06

Page/Seite: 1/1

Purchaser/Kund/kare/besteller
XXX
XXXXXXXXXXXXXXX
XX - XXXXX BXXXXXXXXXXXXXXX

Purchase order No./Bestallnings-Nr./Bestell-Nr.
95145 from 2005.04.14

Works Order No./Order nummer/Auftrags-Nr.
269019 Pos 0010 from 2005.04.15

Dispatch note/Leveransnot/Lieferschein
80177645 from 2005.07.04

Requirements/Krav/Anforderungen
acc. to the regulations or specifications are fulfilled

Object of tests/Testobjekt/Prüfgegenstand
SPRING STEEL UHB 20C
HARDENED AND TEMPERED
WHITE "6" SURFACE
DESURRED EDGES
TENSILE STRENGTH 1960 N/MM2 +/-100
WIDTH B1 THICKNESS T1 FLATNESS P2 STRAIGHTNESS R2
COILS

Volume of delivery/Leveransvolym/Umfang der Lieferung

Pos	Dimension	Weight kg / Gewicht kg	Heat No. / Schmelze	Mfg ord. / Fert-Auf.
	Batch/Parti/Charge Ring no./Ringnr.			
10	THICKNESS: 0,254 MM WIDTH: 40,000 MM 5000144176	117,00	55980	433012

Chemical Composition/Kemisk sammansättning/Chemische Zusammensetzung (%)

Heat No.	C	SI	MN	P	S
55980	0,950	0,230	0,440	0,008	0,0010

Mechanical Properties/Mekaniska egenskaper/Mechanische Eigenschaften

Test No. Prüf-Nr.	Probe No.	Rp N/mm2	Rm N/mm2 1910/1970	A. %	Hardness	Flatn %	Clean %	RA um	RY um

Hereby is certified that the delivery has been manufactured and inspected according to order conditions
Härmed intygas att leveransen har tillverkats och kontrollerats enligt köpeavtal
Hiermit wird bestätigt, dass die Lieferung gemäss Bestellbedingungen hergestellt und abnahmegeprüft worden ist

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Spring Steel
Shock Absorber Steel

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Guide for strip users

Carbon vs. stainless

Carbon is normally the most cost-efficient alternative.

However stainless is the best choice in case of
- corrosion
- high working temperatures (> 200°C)
- severe fatigue
- abrasive wear
- special need for toughness and less notch sensitivity

Calculations

Calculation of strip weight:
kg = 0.0078 x width [mm] x thickness [mm] x length [m]
lbs = 3.38 x width [inch] x thickness [inch] x length [ft]

Straightness deviation:

To convert straightness deviation from one measuring length to another the following formula can be used:

$$R_1 = R_2 \left(\frac{L_1}{L_2} \right)^2$$

R1 = straightness deviation measured on length L1

R2 = straightness deviation measured on length L2

Blanking force (P):

P = C x Rm x L x T
C = approx. 0.80
Rm= tensile strength
L = length of blanked edge
T = strip thickness

(if Rm is in MPa, L and T in mm the blanking force P will be obtained in Newton)

Conversion factors

Kilogram into pound:
Multiply by 2.20482

Pound into kilogram:
Multiply by 0.453692

Metre into foot:
Multiply by 3.28084

Foot into metre:
Multiply by 0.3048

Millimetre into inch
Multiply by 0.03937

Inch into millimetre:
Multyply by 25.4

Micron into micro inch:
Multyply by 39.37

Micro inch into micron:
Multyply by 0.0254

Newton per square millimetre [N/mm2] into pound per square inch [psi]:
Multiply by 145

°C into °F:
1.8 x °C + 32 = °F

°F into °C:
0.5556 x (°F - 32) = °C

BÖHLER UDDEHOLM
precision *strip*

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