

Seamless tubes for Hydraulic Cylinders applications







Hydraulic

cylinders

Tenaris products for hydraulic cylinders

Tenaris produces a wide dimensional range of cold drawn and hot rolled seamless tubes used for hydraulic cylinder applications such as barrels, piston rods and accumulators for different market segments like Earth Moving Machinery, Cranes and Energy.

Our steel grades and manufacturing processes have been optimized to comply with the most demanding conditions, with enhanced features like:



Improved fatigue life



Increased working pressure and reliability



Excellent mechanical properties

(up to 700 MPa yield strength)



High toughness at very low temperatures

(such as arctic applications at -40°C)



Wide tube dimensional range

All Tenaris products are manufactured under a unique Quality Management System certified to ISO 9001.



A reliable partner focused on quality

Thanks to its fully integrated global network, Tenaris can ensure product reliability and process control throughout the entire manufacturing cycle, from definition of the steel chemical properties through the production of the finished component. We are equipped to respond quickly to customers' specific needs, guaranteeing material tracking and constant quality control.

Tenaris offers customized solutions with sophisticated products and product optimization to simplify the manufacturing process of the final component.

Tenaris offers an expansive dimensional range of cold drawn tubes up to 400 mm OD with very tight tolerances.

The use of cold drawn tubes reduces the machining costs, representing a valid alternative to hot rolled tubes heavily machined.



**RENEWABLE
ENERGY**

TENARIS HIGHLIGHTS

Extended dimensional range up to 400 mm OD

High steel grades for high fatigue life

Vertical integration



RENEWABLE ENERGY

As part of the transition towards renewable energy, we provide high precision cold drawn seamless tubes to be used in wind and solar energy applications. Our steel grades are designed according with the latest regulations.



EARTH MOVING MACHINERY

Hydraulic cylinders are integral to the safe, effective use of earth moving machinery. Tenaris developed steel grades with high strength and toughness that perform at low temperatures and maintain structural integrity after multiple work cycles under extreme environmental conditions.



CRANES

Our tubes for hydraulic cylinder barrels are used as telescopic cylinders in applications like all-terrain cranes, capable of maintaining safe, reliable operations even at low temperatures.



EARTH MOVING MACHINERY



CRANES

Product development focused on high fatigue life

Tenaris has developed steel grades (HFL) with excellent strength and toughness to guarantee safe operations even after multiple machining cycles and low temperatures. Our seamless steel tubes feature increased fatigue resistance to ensure structural integrity and reliability throughout the entire component's life.

Steel grade performance for hydraulic cylinders is conducted at Tenaris's R&D centers through both small-scale and full-scale fatigue testing to study crack propagation on the real component.



Additional services and vertical integration

To better serve our customers and optimize their supply chain, Tenaris offers additional services including cut to length, skiving and roller burnishing machining, machined component or welding assembly. Our European-dedicated component centers, equipped with cutting-edge equipment for various operations, can produce the liner ready for assembling on the hydraulic cylinders.

Our laboratories perform dimensional controls, inspecting products and utilizing nondestructive tests to guarantee weld conformity.



Towards the future of sustainable steel

Tenaris's commitment to the environment

Develop a long-term sustainable business model

Prevent pollution and use resources more efficiently

Minimize the environmental impact of our products and services

KEY ACTIONS

REDUCED
AIR
EMISSIONS



Low NOx emission combustion systems and advanced filtration systems

RESOURCE
SAVINGS



Advanced systems to recycle energy, waste and industrial water

ENVIRONMENTAL
MANAGEMENT
SYSTEMS



ISO 14001 certified environmental management system

ENVIRONMENTAL
PRODUCT
DECLARATIONS

EPD[®]



TENARIS HIGHLIGHTS

-30% of CO₂ intensity per ton of steel by 2030

Increase scrap use

Energy efficiency

SYSTEM CERTIFICATIONS

ISO 9001:2008

Quality Management System

ISO 14001:2015

Environmental Management System

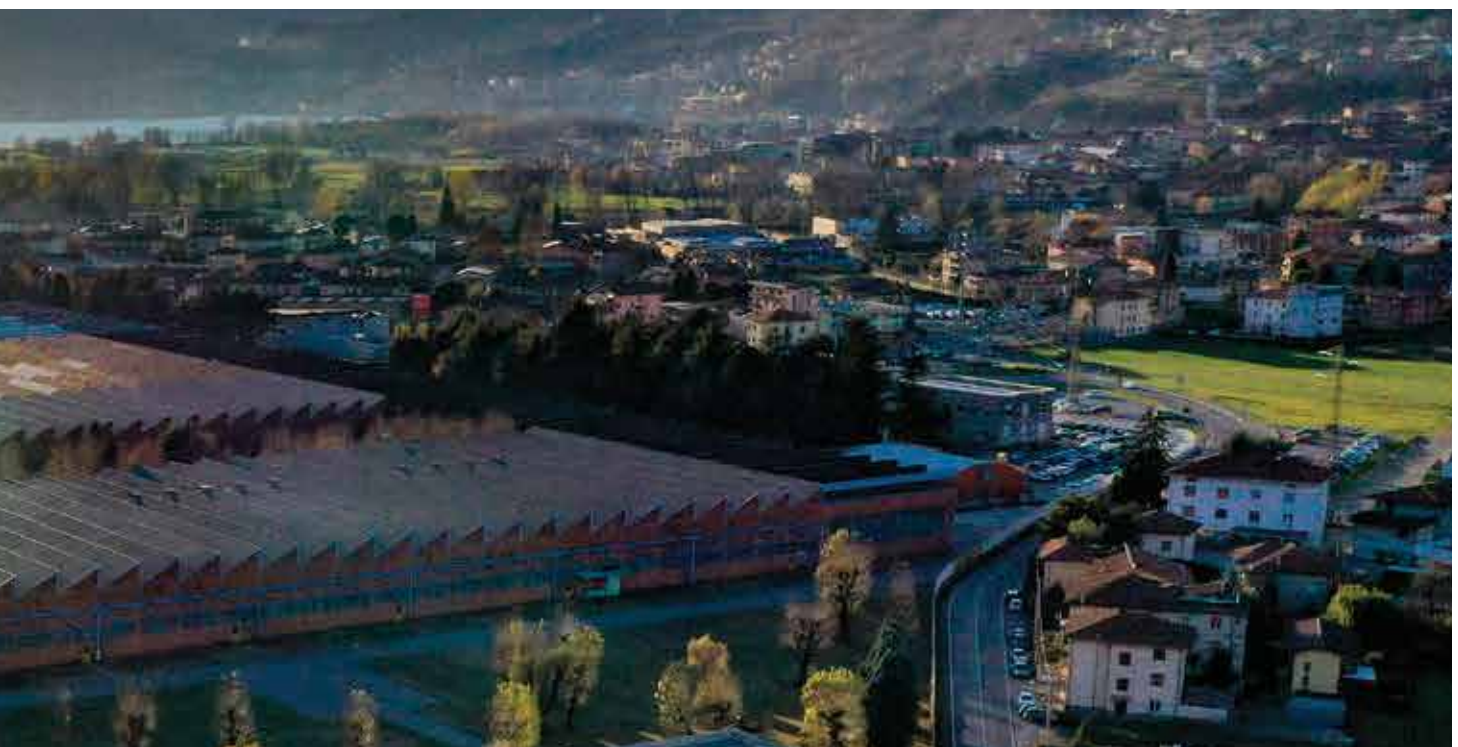
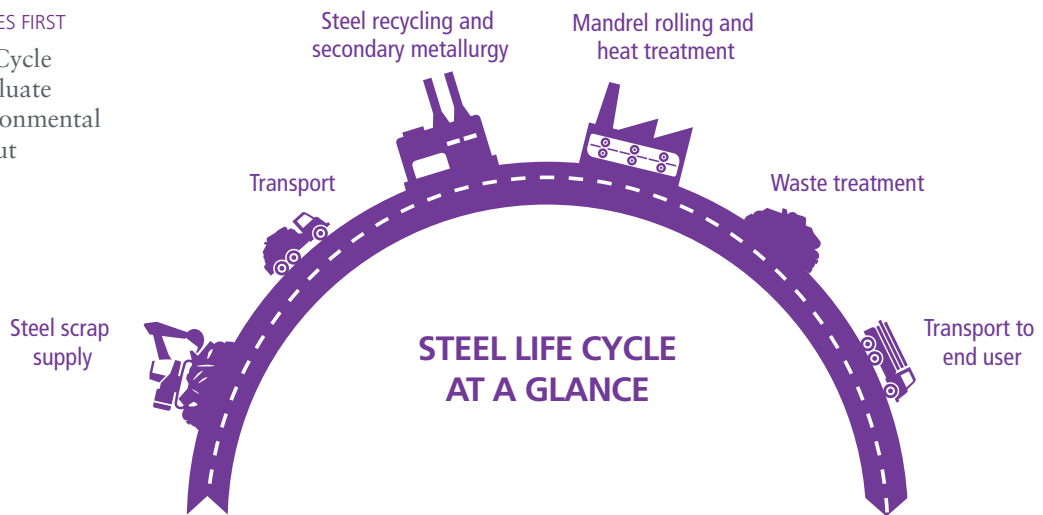
OHSAS 18001:2007

Health & Safety Management System

ISO 50001:2011

Energy Management System

TRANSPARENCY COMES FIRST
Tenaris uses Life Cycle Assessment to evaluate its products environmental impacts throughout the life cycle







Details

Cold Drawn seamless tube for Hydraulic Cylinder Barrel

REFERENCE DOCUMENTS

This material specification is based on EN 10305-1, with modifications and additional requirements stated within this document. Therefore, compliance with the above stated Standard is not envisaged.

The Standards listed below form part of this specification to the extent specified herein. Unless otherwise indicated, latest editions shall be used.

EN 10305-1	Steel tubes for precision applications
EN 10020	Definition and classification of grades of steel
EN ISO 377	Steel and steel products – Location and preparation of samples and test pieces for mechanical testing
ISO 6892-1	Metallic material – Tensile testing
ISO 148-1	Metallic material –Charpy pendulum impact test
ISO 10893-2	Automated eddy current testing of seamless steel tubes
ISO 10893-10	Automated ultrasonic testing of seamless steel tubes
EN 10204	Metallic products – Types of inspection documents
ISO 286-2	ISO system of limits and fits - Part 2 : Tables of standard tolerance grades and limit deviations for holes and shafts



PRODUCT DESIGNATION

The designation of tubes covered by this Specification consists in an alphanumeric code that includes information regarding grade, dimensions, etc..

Product designation shall be as follows:

TN
 [Specification]
 [Grade]
 [Dimensions]
 [Option]

Where:
 TN Stands for “Tenaris”

[Specification] PSP39311/1 - this specification code

[Grade] HCxxx, where xxx is the minimum guaranteed yield strength in MPa.

[Dimensions] yyy.yy x zzz.zz where yyy.yy and zzz.zz are the tube outside and inside diameters respectively, in mm

[Option] see option 1, 2 and 3 in the next paragraphs

Examples:
 TN PSP39311/1
 HC355
 150.00 x 130.00
 Option 1

Tubes produced according to this Specification, in grade HC355 and an outer diameter of 150.00 mm and inside diameter of 130.00 mm. Option 1 means that Impact requirement are guaranteed also at - 40°C

TN PSP39311/1
 HC560 HFL
 250.00 x 220.00
 Option 3

Tubes produced according to this Specification, in grade HC560 HFL (High Fatigue Life), outer diameter of 250.00 mm and inside diameter of 220.00 mm, Option 3 means skived and burnished in the ID.

ABBREVIATIONS

The following abbreviations are used within this document:

N	normalizing heat treatment
SR	stress relieving heat treatment
OD	tube outer diameter
ID	tube inner diameter
W	specimen width
WT	tube wall thickness
H8, H9, H10, H11	ISO tolerance in accordance with ISO 286-2
PO	Production Order
HFL	High Fatigue Life
EC	Eddy current
US	Ultrasonic test

REQUIREMENTS

Manufacturing method

Tubular material covered by this Specification shall be manufactured by the following processes.

Steel Making

Melting shall be done in the EAF (Electric Arc Furnace), with EBT (Eccentric Bottom Tapping) system. Aluminum de-oxidation practice shall be used to produce fine grain fully killed steel. Liquid steel refining shall be done by control of the slag and Argon gas bubbling in the Ladle Furnace and if necessary liquid steel shall be vacuum degassed. Bars shall be manufactured by continuous casting.

Rolling

Seamless steel tubes shall be manufactured by piercing and rolling solid steel bars. All rolling operations shall be done under hot conditions by retained mandrel mill, floating mandrel mill or plug mill processes.

Cold Drawing

After hot rolling, tubing shall be cold drawn in order to achieve final dimensions.

Heat Treatment

After cold drawn process tubing shall be heat treated to achieve mechanical properties stated within this specification. The heat treatment shall be performed in automated lines, with the heat treatment cycle defined according to pipe diameter, wall thickness and steel grade.

Straightening

Tubing shall be straightened to achieve final straightness.

Skiving and Burnishing

If required, the ID of the tubes shall be worked by skiving and roller burnishing after the cold drawing process in order to obtain the desired inner surface quality and tolerances. Upon specific request ID can be worked by honing.

MATERIAL REQUIREMENTS

Chemical composition

Each grade shall be manufactured and shall conform to the chemical composition stated in Table 1 for heat analysis

Grade	C	Mn	Si	P	S
HC355	<=0,20	<=1,60	<=0,50	<=0,025	<=0,020
HC460	<=0,21	<=1,70	<=0,50	<=0,025	<=0,020
HC520	<=0,20	<=1,60	<=0,50	<=0,025	<=0,020
HC520 HFL					
HC560	<=0,21	<=1,70	<=0,50	<=0,025	<=0,020
HC560 HFL					
HC620	<=0,21	<=1,70	<=0,50	<=0,025	<=0,020
HC620 HFL					
HC650 HFL	<=0,21	<=1,70	<=0,50	<=0,025	<=0,020
HC700 HFL	<=0,21	<=1,70	<=0,50	<=0,025	<=0,020

Delivery conditions

Tubing conforming to this specification is supplied in two different delivery conditions: normalized * (+N) and stress relieved (+SR). The combinations of delivery conditions and grades covered by this Specification are listed under Table 2.

(*): For the purpose of this document “normalized and tempered” heat treatment is considered equivalent to “normalized” condition

Tensile requirements

The tensile properties of the different steel grades are listed in Table 2. Tensile testing shall be performed in accordance with ISO 6892-1.

Grade	Trt	Rp0.2% or ReH min [MPa]			UTS min [MPa]			Elong. %
		WT ≤16	25>=WT>16	WT>25	WT ≤16	25>=WT>16	WT>25	
HC355	N	355	355	345	490 ÷ 630			22
HC460	N	460	440	440	560 ÷ 730			22
HC520	SR	520	490	460	600	580	560	15
HC520 HFL	SR							
HC560 (a)	SR	560	540	520	670 ÷ 820	650 ÷ 820	630 ÷ 800	15
HC560 HFL (a)	SR							
HC620	SR	620	590	550	700	680	650	15
HC620 HFL	SR							
HC650 HFL	SR	650	620	-	700 ÷ 900	660 ÷ 900	-	15
HC700 HFL (b)	SR	700	650	-	750 ÷ 950	700 ÷ 950	-	15

Notes:

- (a) Grades HC560 and HC560 HFL available for WT ≥ 7,5 mm
- (b) Grade HC700 HFL is available upon request

MATERIAL REQUIREMENTS (continues)

Impact toughness

For grades indicated in Table 3, material is produced with minimum guaranteed values of impact toughness, measured with a Charpy V-notch impact test. Minimum energy requirements are also indicated in Table 3. Impact tests shall be carried out in accordance with ISO 148-1.

Grade	KV min at -20°C [Joules]		KV min at -40°C [Joules]	
	Long	Transv	Long	Transv
HC355	40	27	40 [Option 1]	27 [Option 1]
HC460	40	27	40 [Option 1]	27 [Option 1]
HC520	27	-	-	-
HC520 HFL	[Option 2]			
HC560	40	27	-	-
HC560 HFL				
HC650 HFL	90	60	27 [Option 1]	27 [Option 1]
HC700 HFL	90	60	27 [Option 1]	27 [Option 1]

Option 1: Upon request grades HC355, HC460, HC650 HFL and HC700 HFL can be supplied with impact toughness guaranteed at - 40°C as per Table N°3

Option 2: Upon request grades HC520 and HC520 HFL can be supplied with impact toughness guaranteed at – 20°C as per Table N°3

The impact test values indicated are meant to be calculated as the average of the three samples of size $W = 10$ mm. At most one individual value may be below the minimum, but not less than 70% of that value. If tube dimensions do not allow full size testing, sub-size specimens shall be used. The energy requirement will be proportionally reduced with specimen area. If sub-size specimen has to be used the largest possible one – close to tube wall thickness - shall be selected. Minimum sub-size specimens to be used shall be $W = 2,5$ mm.

Test pieces shall be taken transverse to the tube axis unless tubes are too small, in which case longitudinal test pieces shall be used. For tubes with a nominal wall thickness smaller than 5.0 mm longitudinal test will be not performed.

The criterion to select the Charpy specimens shall be as follows:

1. full size transversal, if not possible;
2. sub size transversal, if not possible;
3. full size longitudinal, if not possible;
4. sub size longitudinal, if not possible;
5. no test performed.

In the cases 1 and 2, when tube dimensions allow to perform the impact test in transversal direction, the test in longitudinal will not be executed.

For grades not mentioned in Table 3, the impact toughness is not guaranteed.

TEST FREQUENCY

Testing frequency shall be according to Table 4.

Test	Grade	Frequency
Chemical Analysis	All grades	1 heat analysis per heat
Tensile and impact	HC355, HC460, HC520, HC520 HFL, HC560, HC560 HFL, HC620, HC620 HFL	1 test every 400 mother tubes of the same heat and PO confirmation/item
	HC650 HFL, HC700 HFL	1 test every 200 mother tubes of the same heat and PO confirmation/item

Mother Tube: length of tubing as being processed during heat treatment.
A mother tube may comprises more than one cut to length finished tube
Testing may be performed with higher frequencies upon agreement.



DIMENSIONS

Sizes and Tolerances

For the scope of this specification nominal dimensions are meant the dimensions of the finished (after ID machining) cylinder barrel. Tubes shall be produced with tolerances on OD and ID with a controlled Eccentricity.

For all grades the OD tolerances are shown in Table 5. These tolerances are compliant with EN 10305-1. OD and ID ovality shall be within the diameters tolerances.

O.D.	O.D. Tol	O.D.	O.D. Tol
(up to and including)	+/-	(up to and including)	+/-
30	0,08	180	0,90
40	0,15	200	1,00
50	0,20	220	1,10
60	0,25	240	1,20
70	0,30	260	1,30
80	0,35	280	1,40
90	0,40	300	1,50
100	0,45	320	1,60
120	0,50	340	1,70
140	0,70	360	1,80
160	0,80	380	1,90
		400	2,00

Tubes are manufactured with dimensional range, nominal dimensions and ID tolerance as indicated in Tables 6 -7 -8 (dimension in mm). The values inside the boxes represent the OD.



Table 6.
Feasibility matrix
for grades
HC355, HC520

ID tolerances

- 0,15 / -0,35
- 0,20 / -0,40
- 0,20 / -0,45
- 0,25 / -0,55
- 0,40 / -0,70
- 0,50 / -0,90
- 0,50 / -1,00
- 0,60 / -1,40
- 0,70 / -1,40
- 0,80 / -1,60
- 1,00 / -2,00

Upon request

Grade HC355

Tubes are manufactured with dimensional range, nominal dimensions and ID tolerance as indicated in Tables 6-7-8 (dimension in mm). The values inside the boxes represent the OD.

ID/WT	5	6	7,5	10	12,5	15	17,5	20	22,5	25	27,5	30	32,5
20	30	32	35	40									
25	35	37	40	45									
30	40	42	45	50									
32	42	44	47	52									
35	45	47	50	55									
40	50	52	55	60									
45	55	57	60	65									
50	60	62	65	70	75								
55	65	67	70	75	80	85							
60	70	72	75	80	85	90							
63	73	75	78	83	88	93							
65	75	77	80	85	90	95							
70	80	82	85	90	95	100							
75	85	87	90	95	100	105							
80	90	92	95	100	105	110	115						
85	95	97	100	105	110	115	120						
90	100	102	105	110	115	120	125						
95	105	107	110	115	120	125	130						
100	110	112	115	120	125	130	135	140					
105	115	117	120	125	130	135	140	145					
110	120	122	125	130	135	140	145	150					
115	125	127	130	135	140	145	150	155					
120	130	132	135	140	145	150	155	160	165				
125	135	137	140	145	150	155	160	165	170				
130	140	142	145	150	155	160	165	170	175				
135	145	147	150	155	160	165	170	175	180				
140	150	152	155	160	165	170	175	180	185				
145	155	157	160	165	170	175	180	185	190				
150	160	162	165	170	175	180	185	190	195				
155	165	167	170	175	180	185	190	195	200				
160	170	172	175	180	185	190	195	200	205	210			
165	175	177	180	185	190	195	200	205	210	215	220		
170	180	182	185	190	195	200	205	210	215	220	225		
175	185	187	190	195	200	205	210	215	220	225	230		
180	190	192	195	200	205	210	215	220	225	230	235	240	
185	195	197	200	205	210	215	220	225	230	235	240	245	
190	200	202	205	210	215	220	225	230	235	240	245	250	
195	205	207	210	215	220	225	230	235	240	245	250	255	260
200	210	212	215	220	225	230	235	240	245	250	255	260	265
205			220	225	230	235	240	245	250	255	260	265	270
210				230	235	240	245	250	255	260	265	270	275
215				235	240	245	250	255	260	265	270	275	280
220				240	245	250	255	260	265	270	275	280	285
225				245	250	255	260	265	270	275	280	285	290
230				250	255	260	265	270	275	280	285	290	295
235				255	260	265	270	275	280	285	290	295	300
240				260	265	270	275	280	285	290	295	300	305
245				265	270	275	280	285	290	295	300	305	310
250				270	275	280	285	290	295	300	305	310	315
260					285	290	295	300	305	310	315	320	325
265						295	300	305	310	315	320	325	330
270						300	305	310	315	320	325	330	
275							310	315	320	325	330	335	
280							315	320	325	330	335	340	
285							320	325	330	335	340	345	
290							325	330	335	340	345	350	
295							330	335	340	345	350	355	
300							335	340	345	350	355	360	
305							340	345	350	355	360		
310							345	350	355	360	365		
315							350	355	360	365	370		
320								360	365	370	375		
325								365	370	375			
330								370	375	380			
335								375	380	385			
340								380	385				
345								385	390				
350								390	395				
355								395	400				
360								400					

Table 7.
Feasibility matrix
for grades
HC460, HC560 (a),
HC620

ID tolerances

- 0,15 / -0,35
- 0,20 / -0,40
- 0,20 / -0,45
- 0,25 / -0,55
- 0,40 / -0,70
- 0,50 / -0,90
- 0,50 / -1,00
- 0,60 / -1,40
- 0,70 / -1,40
- 0,80 / -1,60
- 1,00 / -2,00

■ Upon request

--- Grade HC460

Tubes are manufactured with dimensional range, nominal dimensions and ID tolerance as indicated in Tables 6 -7 -8 (dimension in mm). The values inside the boxes represent the OD.

ID/WT	5	6	7,5	10	12,5	15	17,5	20	22,5	25	27,5	30
20	30	32	35	40								
25	35	37	40	45								
30	40	42	45	50								
32	42	44	47	52								
35	45	47	50	55								
40	50	52	55	60								
45	55	57	60	65								
50	60	62	65	70	75							
55	65	67	70	75	80							
60	70	72	75	80	85							
63	73	75	78	83	88							
65	75	77	80	85	90	95						
70	80	82	85	90	95	100						
75	85	87	90	95	100	105						
80	90	92	95	100	105	110	115					
85	95	97	100	105	110	115	120	125				
90	100	102	105	110	115	120	125	130				
95	105	107	110	115	120	125	130	135				
100	110	112	115	120	125	130	135	140	145			
105	115	117	120	125	130	135	140	145	150			
110	120	122	125	130	135	140	145	150	155			
115	125	127	130	135	140	145	150	155	160			
120	130	132	135	140	145	150	155	160	165			
125	135	137	140	145	150	155	160	165	170			
130	140	142	145	150	155	160	165	170	175			
135	145	147	150	155	160	165	170	175	180			
140	150	152	155	160	165	170	175	180	185			
145	155	157	160	165	170	175	180	185	190			
150	160	162	165	170	175	180	185	190	195	200		
155	165	167	170	175	180	185	190	195	200	205	210	
160	170	172	175	180	185	190	195	200	205	210	215	220
165	175	177	180	185	190	195	200	205	210	215	220	225
170	180	182	185	190	195	200	205	210	215	220	225	230
175	185	187	190	195	200	205	210	215	220	225	230	235
180	190	192	195	200	205	210	215	220	225	230	235	240
185	195	197	200	205	210	215	220	225	230	235	240	245
190	200	202	205	210	215	220	225	230	235	240	245	250
195	205	207	210	215	220	225	230	235	240	245	250	255
200	210	212	215	220	225	230	235	240	245	250	255	260
205			220	225	230	235	240	245	250	255	260	265
210				230	235	240	245	250	255	260	265	270
215				235	240	245	250	255	260	265	270	275
220				240	245	250	255	260	265	270	275	280
225				245	250	255	260	265	270	275	280	285
230				250	255	260	265	270	275	280	285	290
235				255	260	265	270	275	280	285	290	295
240				260	265	270	275	280	285	290	295	300
245				265	270	275	280	285	290	295	300	305
250				270	275	280	285	290	295	300	305	310
260					285	290	295	300	305	310	315	320
265						295	300	305	310	315	320	325
270						300	305	310	315	320	325	330
275							310	315	320	325	330	335
280							315	320	325	330	335	340
285							320	325	330	335	340	345
290							325	330	335	340	345	350
295							330	335	340	345	350	355
300							335	340	345	350	355	360
305							340	345	350	355	360	365
310							345	350	355	360	365	370
315							350	355	360	365	370	375
320								360	365	370	375	380
325								365	370	375	380	385
330								370	375	380	385	390
335								375	380	385	390	395
340								380	385	390	395	400
345												
350												
355												
360												
ID/WT	5	6	7,5	10	12,5	15	17,5	20	22,5	25	27,5	30

Note:
(a): Grades HC560 and HC560HFL are available for WT>=7,5mm

ID/WT	5	6	7,5	10	12,5	15	17,5	20	22,5	25
95	105	107	110	115	120					
100	110	112	115	120	125	130				
105	115	117	120	125	130	135				
110	120	122	125	130	135	140				
115	125	127	130	135	140	145				
120	130	132	135	140	145	150	155			
125	135	137	140	145	150	155	160			
130	140	142	145	150	155	160	165			
135	145	147	150	155	160	165	170			
140	150	152	155	160	165	170	175			
145	155	157	160	165	170	175	180			
150	160	162	165	170	175	180	185			
155	165	167	170	175	180	185	190			
160	170	172	175	180	185	190	195			
165	175	177	180	185	190	195	200	205		
170	180	182	185	190	195	200	205	210		
175	185	187	190	195	200	205	210	215		
180	190	192	195	200	205	210	215	220		
185	195	197	200	205	210	215	220	225		
190	200	202	205	210	215	220	225	230		
195	205	207	210	215	220	225	230	235		
200	210	212	215	220	225	230	235	240	245	
205		217	220	225	230	235	240	245	250	
210		222	225	230	235	240	245	250	255	260
215			230	235	240	240	250	255	260	265
220			235	240	245	250	255	260	265	270
225			240	245	250	255	260	265	270	275
230			245	250	255	260	265	270	275	280
235			250	255	260	265	270	275	280	285
240			255	260	265	270	275	280	285	290
245			260	265	270	275	280	285	290	295
250				270	275	280	285	290	295	300
260				280	285	290	295	300	305	
265				285	290	295	300	305	310	
270				290	295	300	305	310	315	
275					300	305	310	315	320	
280					305	310	315	320	325	
285					310	315	320	325	330	
290						320	325	330	335	
295						325	330	335	340	
300						330	335	340		
305						335	340	345		
310						340	345	350		
315						345	350	355		
320						350	355	360		
325						355	360			
330						360	365			
335						365	370			
340						370	375			
345							380			
350							385			
355							390			
360							395			
365							400			
ID/WT	5	6	7,5	10	12,5	15	17,5	20	22,5	25

Table 8.
Feasibility matrix
for grade
HC650 HFL

ID tolerances

- 0,50 / -1,00
- 0,60 / -1,40

Upon request

Tubes are manufactured with dimensional range, nominal dimensions and ID tolerance as indicated in Tables 6 -7 -8 (dimension in mm). The values inside the boxes represent the OD.

DIMENSIONS

For all grades the maximum tube eccentricity shall be according to Table 9.

OD [mm]	WT [mm] < 25	WT [mm] >= 25
<= 280	7%	10%
> 280	8%	10%

Whereas eccentricity is measured according to the following formula:

$$\text{Eccentricity} = \frac{WT_{\max} - WT_{\min}}{WT_{\max} + WT_{\min}}$$

Where WT_{\max} and WT_{\min} are the maximum and minimum wall thickness measured on the same tube section

Note: Upon request other dimensions, tolerances and machining allowances can be analyzed.

Length

The minimum and maximum manufacturing lengths are 5.5 and 14.5 m respectively. Tubes are supplied in random lengths within a range of 2 m. The average production length varies according to the OD and ID dimensions.

Manufacture of tubes in fixed lengths or fixed multiple lengths can be agreed upon request. The cutting tolerance for fixed or multiple lengths is $-0 +100\text{mm}$; different cutting tolerances may be agreed upon.

Straightness –Method of deviation from a straight line

• Local deviation from straight line

It shall be measured, as the distance between the tube surface and a ruler 1000 mm long. Maximum allowed is 1 mm per each meter of length.

• Total deviation from straightness

It shall be measured, as the distance between the tube surface and a chord linking both ends of the tube. Maximum allowed is 3.5 mm for tubes with length less than 6 m; for tubes with length greater than 6 m, the tolerance shall be increased by 0.5 mm for each meter over 6 m.

NON DESTRUCTIVE TESTING

Each tube shall be controlled using automatic non destructive equipment.

NDT level has been defined for two families of grades depending on the expected working condition (e.g.: hoop stress and expected fatigue life) of the cylinder barrel:

- Standard grades
- HFL (High Fatigue Life) grades with improved surface quality

Table 10 defines the technique and employed calibration standard for each grade.

	Grades	Techn.	Orient	Position	Calibration				
					Depth			Max length	Max width
					Nominal	Max (mm)	Min (mm)		
Standard grades	HC355	EC	Long.	Ext	5% WT	1,50	0,50	50	0,30
	HC460								
	HC520								
	HC560								
	HC620								
High performance grades	HC520 HFL	EC	Long.	Ext	2 % WT	Nominal	0,30	50	0,30
	HC560 HFL	US	Long.	Ext	2 % WT	Nominal	0,30	25	0,50
	HC620 HFL	US	Long.	Int	5%WT	0,90	0,30	25	0,50
	HC650 HFL								
	HC700 HFL								

Eddy current test shall be performed in accordance with ISO 10893-2; ultrasonic test shall be executed according to ISO 10893-10.

Tubes with indications above the rejection level established in Table 10 shall be segregated. For segregated tubes one of the following actions shall be taken:

1. the suspect area is cropped off;
2. the suspect area is dressed by grinding;
3. the tube is rejected.

Dressed tubes shall be re-inspected by means of the same technique or alternatively by an equivalent technique (e.g. Magnetic Particle Inspection).

The dressed area shall conform to the requested dimensional tolerances.

APPEARANCE

The internal and external surface finish shall be typical of the cold drawn manufacturing process, and where applicable, a skived and burnished surface. All imperfections such as ridges, dents, marks, etc. detected by a visual

examination, whose indications are under rejection level established in Table 10 shall not be considered cause of rejection. External surface grinding is admitted with a smooth finishing.

SPECIAL TESTING

For qualification purposes, special testing (e.g. fatigue endurance test, weldability test, burst test) may be performed upon agreement.

SURFACE PROTECTION

Tubes shall be internally and externally oiled in order to provide temporary protection against rusting in a covered stock-yard for maximum 6 months.

MARKING

The identification of the tubes for cylinder is carried out through the following continuous marking, in indelible ink, along the entire length. The marking will include at least the following information:

- Tenaris XX (where XX is the mill code)
- this specification number
- steel grade + Delivery condition
- nominal OD x ID in mm
- heat number

Different marking can be agreed upon at the time of enquire and order

PACKAGING

Tubes shall be packed in strapped bundles. When the number of tubes is sufficient, hexagonal bundles shall be used. The minimum weight is as shown in Table 11. The maximum weight of the bundle is 6000 kg.

Table 11. Minimum bundle weight

OD [mm]	Min bundle weight (kg)
< 100	1500
100 ÷ 160	2000
> 160	3000

Other packaging alternatives are available upon request.

SKIVED AND BURNISHED TUBES - Option 3

Upon request it is possible to supply skived and burnished tubes with tolerances on the inside diameter in accordance with ISO Standard 286-2, with a maximum surface roughness on the worked surface of 0.30 micrometer Ra. The feasibility range available for skived and burnished tubes is stated in Table 6 - 7 - 8 [in mm].

The internal diameter tolerances shall be guaranteed as per Table 12 as according to internal diameter/wall thickness ratio.

Table 12. ISO tolerances - ID/WT ratio

ID/WT	ID tolerances (ISO 286)
≤ 20	H8
20,1 ÷ 25	H9
25,1 ÷ 28	H10
> 28,1	H11

Upon request we can supply tubes with inside diameter honed, in this case ID tolerances and surface roughness has to be agreed.

DOCUMENTATION

The product is supplied with 3.1 type certificate, in accordance with EN 10204. The certificate shall be issued containing at least the following information:

- Customer
- Manufacturer's Production Order
- Steel grade + Delivery condition
- Chemical Analysis
- Mechanical test result
- Conformance with NDT
- Sample test number

Alternatively, a type 3.2 certification can be agreed upon at time of enquire and order. In this case, the customer must notify at the time of ordering the organization or the individual responsible who must conduct the inspection.

QUALITY ASSURANCE

Tenaris products are manufactured under a Quality Management System certified to ISO 9001

DISCLAIMER OF LIABILITY

Customer hereby acknowledges and agrees that, after delivery of the Goods, customer will proceed, either directly or through third parties, to manufacture tubes for hydraulic cylinder barrel applications and for such purpose the Goods will be subjected to substantial transformation including several mechanical and technical procedures. Consequently, customer shall defend and hold harmless Tenaris and its subcontractors from, against, for and in respect of (i) any loss, liability, claim, damage (including consequential or incidental), asserted or incurred by customer or a third party by reason of any defects in the seamless steel tubing attributable to any act or omission of

customer and (ii) any claim, loss, liability, damage (including consequential or incidental) asserted against Tenaris (including any of its subcontractors) by any third party. If Tenaris receives a claim which customer is obligated to provide indemnification under this provision, Tenaris shall notify customer of such claim and customer shall provide Tenaris with the sums necessary to discharge the amounts payable by Tenaris or its relevant Affiliate or subcontractor (including legal fees and all expenses and costs related thereto).



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