

TAM[®] Plus

According to EN 10297-1



TAM[®] Plus

REFERENCE NORM EN 10297-1
SEAMLESS STEEL TUBES WITH HIGH MACHINABILITY (HL)
AND CLOSE TOLERANCES FOR MECHANICAL APPLICATIONS

TAM[®] Plus is a range of hot rolled mechanical tubes, designed by Tenaris to better meet the needs of industrial sector.

The product, part of the TAM[®] mechanical application tubes family, is the result of extensive R&D expertise and a fully integrated manufacturing process.

Based on research conducted by the Technical Assistance team across a wide range of applications - including cylinders, rollers, bushings, connectors, and gears - a clear need emerged for a product offering enhanced performance beyond standard specifications.

This led to a focused development in the following key areas:

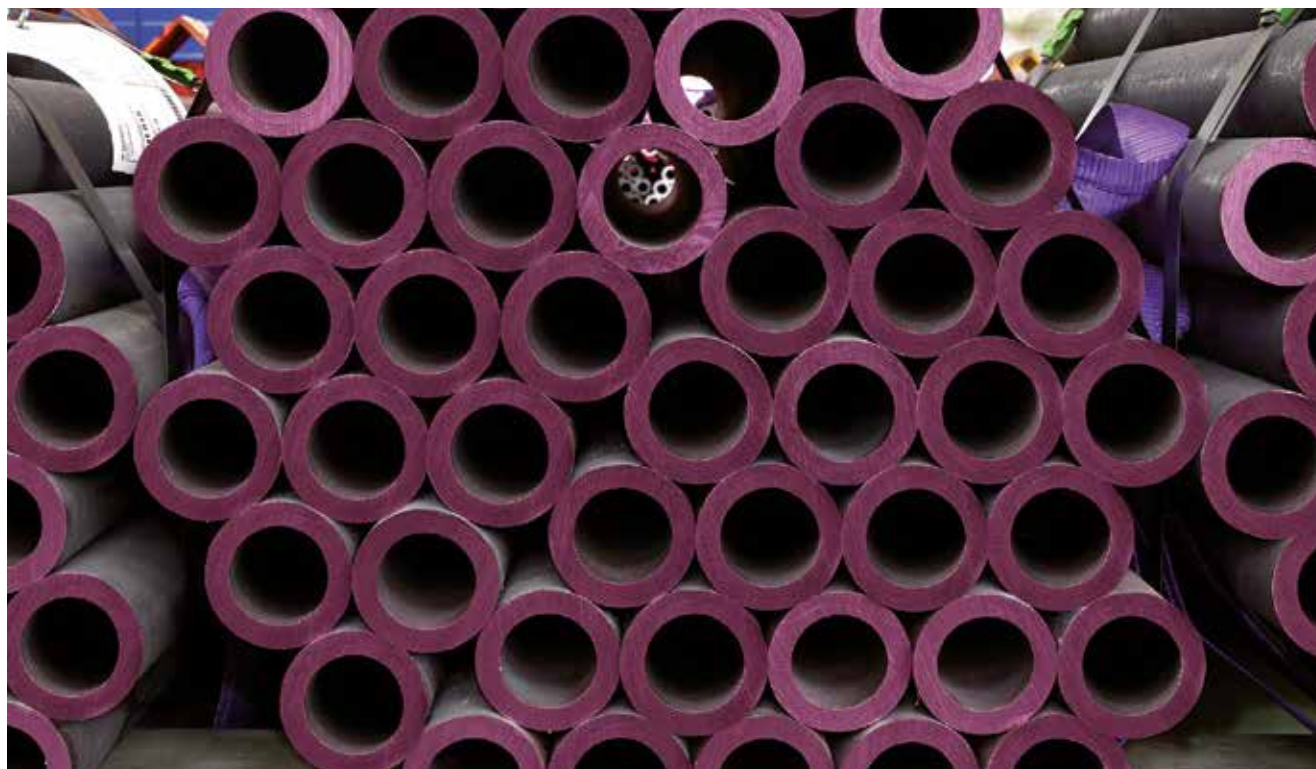
- Machinability (HL)
- Dimensional tolerances
- Straightness

The objective of the project was to ensure control over:

- Metallurgical characteristics
- The production process for a family of steels suitable for machining applications

Within our fully integrated manufacturing process - from steelmaking through tube rolling, cold drawing, heat treatment, and tubular component processing - we focus on designing tailor-made solutions that meet our customers' requirements. This approach ensures longer product life, high mechanical performance, and optimized operations.

A highly skilled Tenaris team provides continuous technical support throughout all stages of product development and after-sales. We deliver added value to every customer request and pursue ongoing product improvement to meet evolving industrial needs.



Production technology

TAM® Plus is produced from fine-grain alloy steel, with guaranteed soluble aluminum and controlled sulfur content.

The use of Electromagnetic Stirring (EMS) enables a more homogeneous billet structure, reducing segregation index and central porosity (Fig. 1 / Fig. 2).

In addition, the automated control of continuous casting parameters ensures enhanced process stability and consistent steel quality.

TAM® Plus tubes are manufactured using the Diescher rolling mill at Tenaris's Arcore plant in Italy.

ADVANTAGES OF THE DIESCHER MILL:

- Tight tube concentricity
- Wide dimensional range in wall thickness



FIG 1 - IMPRINT BAUMAN (NOT EMS)



FIG 2 - IMPRINT BAUMAN (WITH EMS)



TAM® Plus delivers superior technical performance compared to standard solutions, with key advantages in:

- Machinability (HL)
- Close tolerances on wall thickness
- Tight straightness

MACHINABILITY

Machinability is determined by two factors:

1. Material condition

- Chemical and mechanical properties
- Heat treatment method and relevant microstructure
- Inclusion rate
- Surface condition

2. Working conditions

- Cutting speed
- Cutting depth
- Feed rate
- Type of cutting edge

Steel with controlled sulfur content promotes the formation of fine, well-dispersed manganese sulfides. These act as a protective lubricating film between the tool and the material, reducing cutting forces and temperatures, and consequently minimizing tool wear.

Thanks to their high deformability, these inclusions also enhance chip breakability, improving overall machinability.

Tenaris has implemented a dedicated secondary metallurgy practice in steelmaking to modify hard alumina inclusions - unavoidable in microalloyed steels with guaranteed minimum aluminum - into less abrasive forms.

This inclusion engineering minimizes their abrasiveness, thereby reducing tool wear and enhancing overall machining performance.

Machinability economic advantages depend on two factors:

1. Tool life

Improvement in tool life is illustrated below by means of Taylor Curves for steel grades TAM® Plus E 470 HL compared to the same grade non re-sulfured steel.

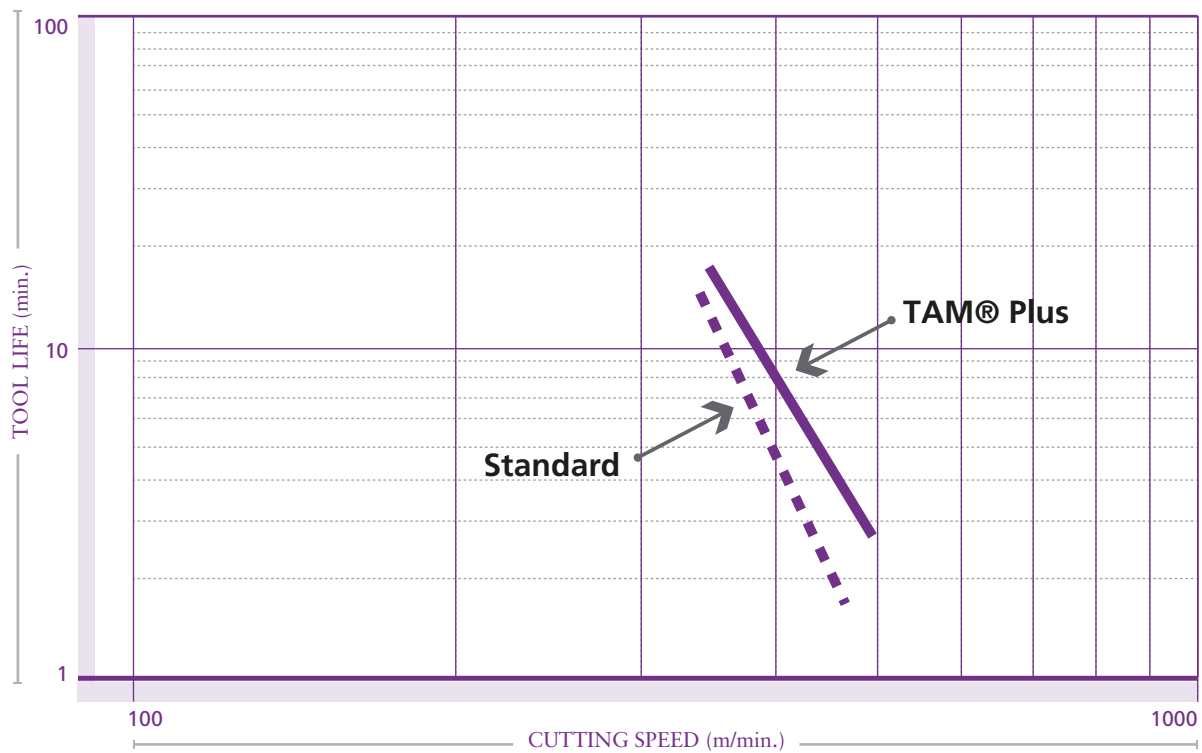
With a tool life conventionally fixed at 10 minutes, the cutting speeds show an increase from 7 to 14%, allowing a considerable increase in the number of pieces produced with the same cutting edge.

2. Chip formation

Experimental tests have shown that in severe working conditions, characterized by wide cutting depth intervals and low feeding rates, the re-sulphured TAM® Plus steel grades permit formation of detached chips.

ADVANTAGES

- Lower tool temperatures, for an equal number of working cycles, with consequent improvement in cutting speed
- Lower cutting edge wear
- Reduction in built-up edge
- Reduction in cutting force and consequent increase in tool life
- Reduction in the number of stops necessary to manually remove the chips and subsequent reduction in injuries associated with this operation
- Elimination of the number of irregular pieces caused by cutting edge wear
- Improvement in surface finish



CHIP SHAPES

1.	2.	3.	4.	5.	6.	7.	8.
Ribbon chip	Tubular chip	Spiral chip	Helical chip of conical type	Helical chip of conical type	Arc chip	Discontinuous chip	Needle chip
1.1	2.1	3.1	4.1	5.1	6.1		
Long	Long	Flat	Long	Long	Attached		
1.2	2.2	3.2	4.2	5.2	6.2		
Short	Short	Conical	Short	Short	Detached		
1.3	2.3		4.3	5.3			
Tangled	Tangled		Tangled	Tangled			

Classification of chip types based on experimental observation according to the standard ISO 3685

CLOSE TOLERANCES ON WALL THICKNESS

Thanks to the Diescher transverse rolling process, Tenaris ensures a high level of dimensional accuracy, with tight tolerances as shown in the annex.

ADVANTAGES

- Complete elimination of unprocessed areas after machining
- Optimized initial tube weight thanks to minimized production wall thickness needed to reach final dimensions

TIGHT STRAIGHTNESS

Process and product controls ensure straightness levels of $\leq 1\%$ cumulative along the full tube length.

ADVANTAGES

- Enhanced centering accuracy, enabling reduced machining allowance
- Lower vibration and oscillation within the machining process
- Reduced machine downtime, improving operational efficiency



APPLICATIONS

GRADE*	Applications
E355 HL	Steel for high machinability mechanical applications
E470 HL	Steel for high machinability and high yield mechanical applications
E420J2 HL	Steel for high machinability mechanical applications with guaranteed toughness
E460K2 HL	Steel for high machinability mechanical applications with guaranteed toughness
C45E HL	Steel for high machinability mechanical applications and tempering
42CrMo4 HL	Steel for high machinability mechanical applications for quench and tempering
16MnCrS5 HL	Steel for high machinability mechanical applications for quench and case hardening
20MnCrS5 HL**	Steel for high machinability mechanical applications for quench and case hardening

* HL = High machinability

** Chemical composition according to EN 10084-1

Note: C45E HL, 42CrMo4 HL, 16MnCrS5 HL and 20MnCrS5 HL can be provided rough (+AR), normalized (+N) and annealed (+A).

CHEMICAL ANALYSIS %

Grade	C	Si	Mn	P	S	V	Cr	Mo	Al Tot.	NB	Ti	Cu	N	Cr+Mo+Ni	Nb+V
E355 HL	≤ 0,20	≤ 0,50	≤ 1,60	≤ 0,030	0,020 - 0,035	-	-	-	-	-	-	-	-	-	-
E420J2 H	0,16 ÷ 0,22	0,10 ÷ 0,50	1,30 ÷ 1,70	≤ 0,030	0,020 - 0,035	0,08 ÷ 0,15	≤ 0,30	≤ 0,08	≥ 0,010	≤ 0,07	≤ 0,05	≤ 0,30	≤ 0,020	-	≤ 0,20
E460K2 HL	≤ 0,20	≤ 0,60	1,00 ÷ 1,70	≤ 0,030	0,020 - 0,035	≤ 0,20	≤ 0,30	≤ 0,10	≥ 0,020	≤ 0,05	≤ 0,05	≤ 0,70	≤ 0,025	-	≤ 0,20
E470 HL	0,16 ÷ 0,22	0,10 ÷ 0,50	1,30 ÷ 1,70	≤ 0,030	0,020 - 0,035	0,08 ÷ 0,15	-	-	-	≤ 0,07	-	-	-	-	-
42CrMo4 HL	0,38 ÷ 0,45	≤ 0,40	0,60 ÷ 0,90	≤ 0,035	0,020 - 0,035	-	0,90 ÷ 1,20	0,15 ÷ 0,30	≥ 0,010	-	-	-	-	-	-
C45E HL	0,42 ÷ 0,50	≤ 0,40	0,50 ÷ 0,80	≤ 0,035	0,020 - 0,035	-	≤ 0,40	≤ 0,10	-	-	-	-	-	≤ 0,63	-
16MnCrS5 HL	0,14 ÷ 0,19	≤ 0,40	1,0 ÷ 1,30	≤ 0,025	0,020 - 0,040	-	0,80 ÷ 1,10	-	-	-	-	-	-	-	-
20MnCrS5 HL	0,17 ÷ 0,22	≤ 0,40	1,10 ÷ 1,40	≤ 0,025	0,020 - 0,040	-	1,00 ÷ 1,30	-	-	-	-	-	-	-	-

* All steel grades are completely calmed

MECHANICAL PROPERTIES

GRADE	DELIVERY CONDITION*	TENSILE PROPERTIES							IMPACT TEST**	
		Rp 0.2 (MPa) min			Rm (MPa) min			A %	Charpy KV long	
		Wall thickness mm			Wall thickness mm			long.	T °C	J MIN
		≤16	>16≤40	>40≤65	≤16	>16≤40	>40≤65	min		
E355 HL	G	355	345	335	490-650	490-650	490-650	20	-	-
E470 HL	G	470	430	430	650	600	600	17	-	-
E420J2 HL	N	420	400	390	600	560	530	19	-20	27
E460K2 HL	N	460	440	430	550	550	550	17	-20	40

* G = as rolled (not treated) - N = normalized - Normalization can be done online or in the furnace.

** The impact test values indicated are meant to be calculated as the average of the three samples of width W = 10 mm. One individual value may be below the minimum, but not less than 70% of that value.

The certificate reports the dimension of the sample and the values measured in the test in J. If the sample width W is less than 10 mm, the minimum requested KV10 values are reduced in the new KVV value according to the formula: KVV=KV10 x (W/10)



DIMENSIONAL TOLERANCES

Outside Diameter and Wall Thickness tolerances are highlighted in the table.

OPTION A

Straightness: 1mm/m cumulated.

LENGTHS

Tubes are supplied in commercial lengths.

OPTION B

Lengths different from the standard can be agreed at the time of order.

SERVICE CENTER

Tenaris Service Center can supply tubes cut fixed lengths with tolerances of $-0 / +3$ mm. Cut Squareness: 1,5 mm.

CHECKS

The product is subjected to the following tests:

- Mechanical tests in accordance with reference standards
- Electromagnetic test according to EN 10893-3 on longitudinal direction
- Visual and dimensional check on each tube
- Anti Mixing control

SURFACES

The product is supplied with hot finished surfaces, as rolled.

CERTIFICATION

The product is supplied with 3.1 Inspection Certificate, in conformity with EN 10204. Full product traceability guaranteed.

IDENTIFICATION AND MARKING

TAM® PLUS mechanical tubes are identified as follows:

Continuous paint marking (white):

- Manufacturer's trade mark
- TAM® PLUS
- Steel grade
- Reference norm
- OD x WT
- S (production process)
- Heat
- Internal mill order number

Die stamping:

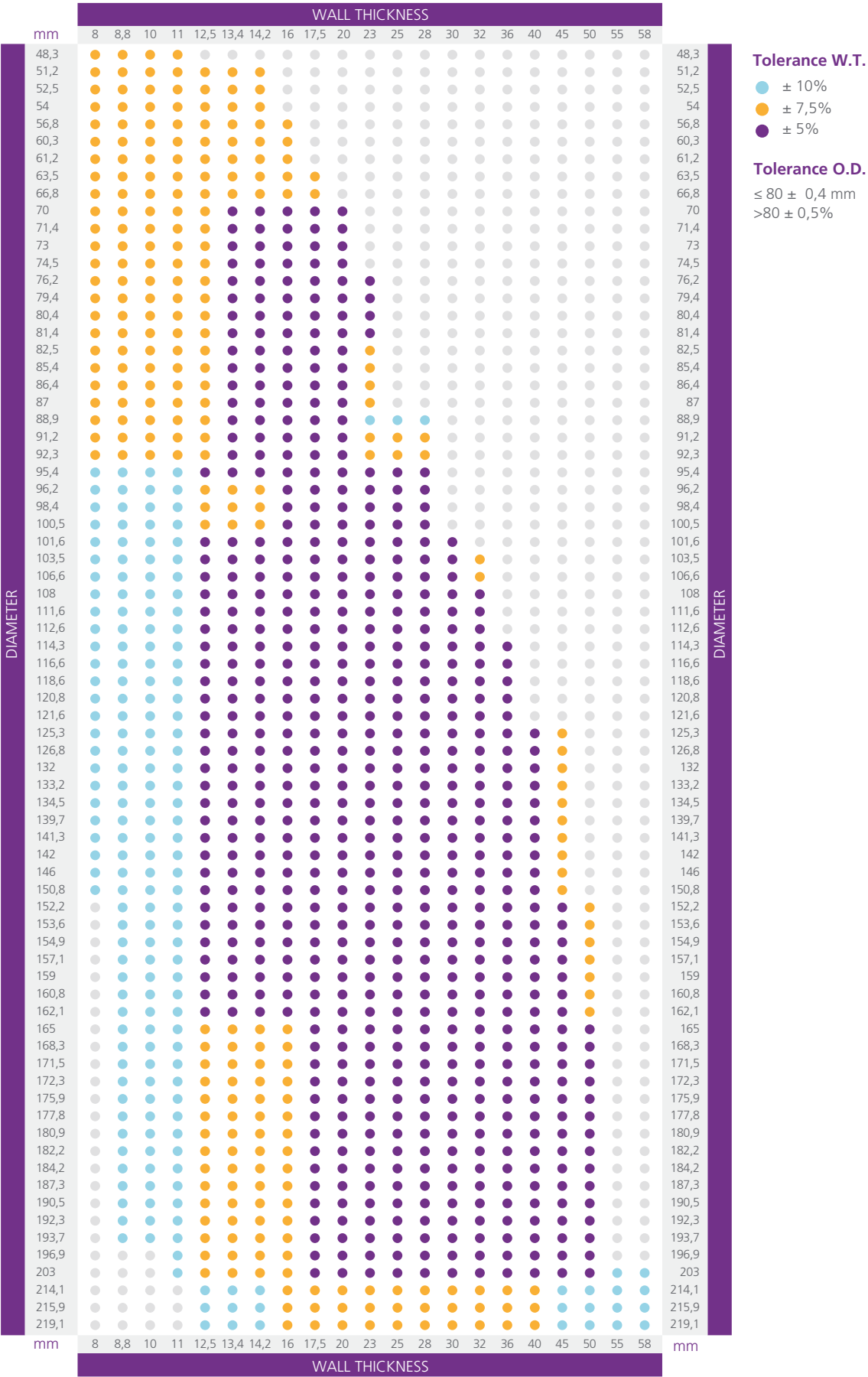
- Manufacturer's trade mark
- TAM® PLUS
- Steel grade
- S (production process)
- Mill inspector.

Application of Tenaris pink paint on both tube ends.

PACKAGING

Tubes are supplied in bundles secured with straps. Tenaris offers technical assistance for the development of customized product applications.

Dimensional Tolerances



Tenaris technicians are at your disposal in order to point the dimension of initial tube that guarantees achievement of finished size after mechanical working. All thicknesses can be continuously produced.



For further information

www.tenaris.com

For assistance please contact

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