



Industrial Services &
Automotive

TAM[®] Plus





Quality System Certified
n. 110950

TAM[®] Plus



Norme of reference EN 10297-1 Seamless tubes with high machinability (HL) and closed tolerances for mechanical applications

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

The new product, which is part of the TAM[®] family (Mechanical Application Tubes), is the result of a project coordinated by TenarisDalmine R&D department and has also involved the commercial and production organizations.

Following a research carried out by the technical assistance area in various application fields,

including cylinders, rollers, bushing, connectors and gears, the need for a product having characteristics superior to the standard came to light in the following areas emerged:

- Straightness
- Machinability
- Concentricity

The project had the goal of checking:

- The metallurgical characteristics
- Production procedures for a family of steel suitable for machine tool working.

Therefore a product with re-sulfured steel, close

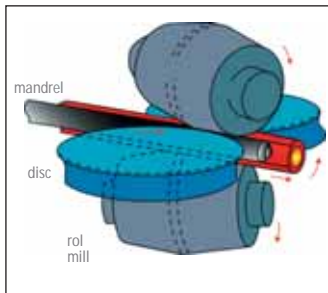
tolerances and good straightness (1% cumulative on the tube length) was defined.

Fusion and casting procedure was set up during the production process to obtain a minimum inclusion level, with uniform distribution of sulphur in order to improve the steel machinability.

Thanks also to the Diescher mill in our production unit located in Arcore, TAM[®] Plus is the most suitable product for mechanical applications in 48 – 203 mm dimensional range.



Production technology



Tenaris presents a new, highly machinable product TAM® Plus

TAM® Plus is produced from fine grain alloy steel with guaranteed soluble aluminum and controlled sulfur contents (0.020-0.035). It is intended for various areas of application.

In producing TAM® Plus tubes, the technology of the Arcore plant plays a key role:

- Piercer mill
- Diescher mill

The piercer mill is the machine that transforms – at high temperature – the primary material (round bar from continuous casting) into a hollow with heavy wall thickness and good concentricity. The Diescher mill, by means of transverse rolling, permits a hollow of lower wall thickness and even better concentricity to be obtained.

The diameter of the hollow is defined by means of the positioning of the rolling cylinders and the guiding discs; the wall thickness is defined by the position of the cylinders and the

internal mandrel. After the Diescher Mill, the finished diameter of the tube is defined:

- For the dimensional range 48.3 – 101.6 the tubes pass through an intermediate heating furnace and then to the stretch reducing mill (SRM) that can also alter the wall thickness in a controlled manner;
- For the dimensional range 101.6 – 203 the tubes are brought directly to the required diameter by a sizing mill, without any significant variation in wall thickness.

Advantages of the Diescher mill

- Tube concentricity
- Wide wall thickness dimensional range



Industrial investments

TenarisDalmine, consistent to its policy of continuous improvement, has carried out a series of investments and operations in:



Steelworks

- Introduction of the Electromagnetic Stirrer, making it possible to obtain a bar with a more homogeneous structure and lower segregation index and central cavity porosity (Fig 1/fig2)
- New automatic control of the continuous cast parameters allowing better process control and steel quality



Fig 1
Bauman Impression
(without EMS)



Fig 2
Bauman Impression
(wit EMS)

Arcore Rolling Mill

- The automation and process controls have been completely renovated, right from the bar heating furnace throughot to the finishing lines.
- Installation of radioisotopeequipment to continuously control the thickness along the entire length of the tube, during the hot rolling process
- Complete automisation for moving tubes along the entire production line



TAM® Plus offers technical characteristics above the standard for:

- Machinability
- Close tolerances on the diameter and thickness
- Straightness

Machinability

Determined by two factors:

- Condition of the materials
 - Chemical and mechanical properties
 - Heat treatment method and consequent micro-structure
 - Inclusion state
 - Surface condition
- Working conditions
 - Cutting speed
 - Cutting depth
 - Feed rate
 - Type of cutting edge, tool holder, machine.

Manganese sulphide inclusions present in the steel, slow down the cutting edge wearing out and favor chip breaking (the opposite of using steel with calcium aluminate inclusions or other refractory materials, which are hard and abrasive).

Tenaris, in its R&D laboratories neutralized the undesirable alumina in the steel and added controlled quantities of sulfur, an element able to form manganese sulphide. The sulphur acts as a lubricant between tool and chip surface, facilitating machinability, while the high softening temperature of the manganese sulphide makes the steel suitable for use at high

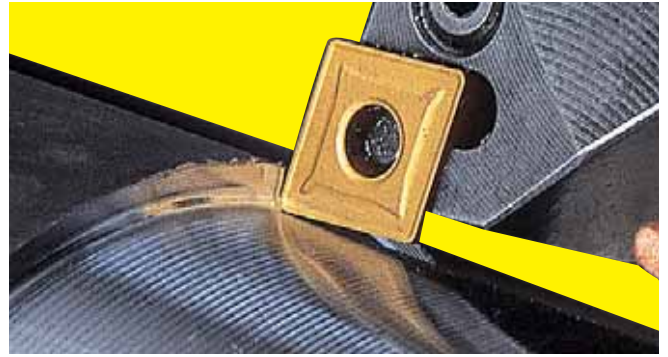
cutting speeds.

Machinability of Tenaris steel is measured by:

- Tool life tests
With a tool life conventionally fixed at 10 minutes, laboratory tests have demonstrated that steel that has undergone re-sulfurisation is more machinable compared to standard steel, permitting greater machining speeds.
- Chip formation tests
Formation of short, detached chips guaranteed by using re-sulphured steel allows high machining speeds with consequent reduction in time and production costs.

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

Classification of chip types based on experimental observation according to the standard (The ideal chip types are shown in green)



The economic advantages of the machinability depend on two factors

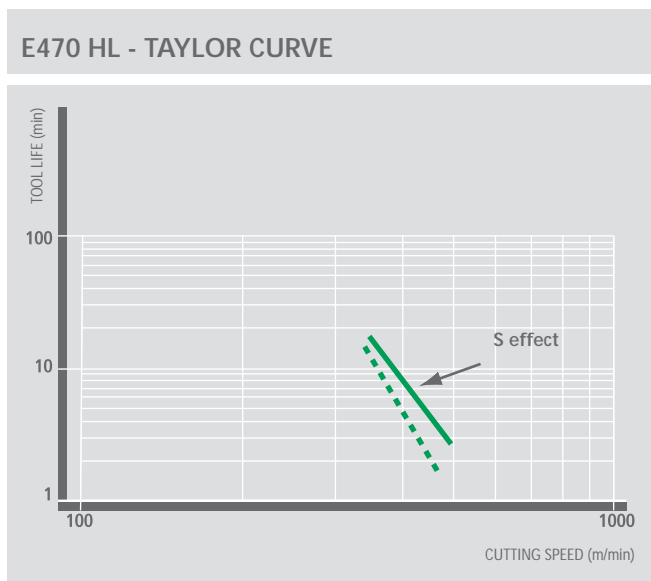
- Tool life

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

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

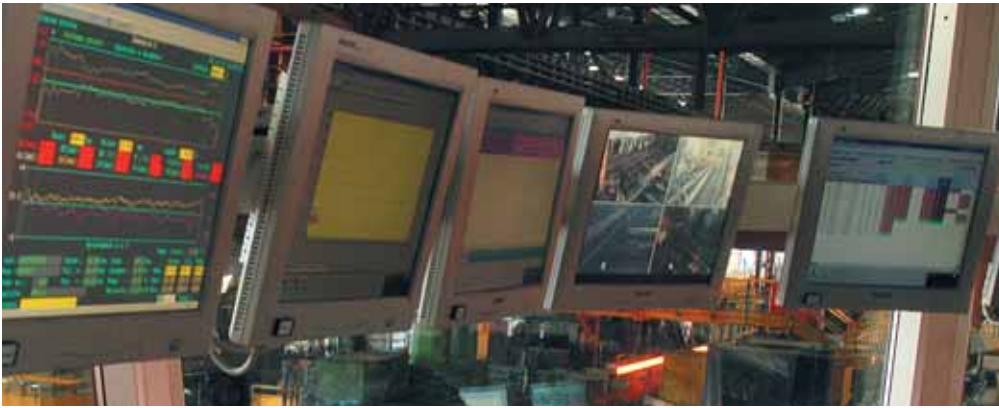
- Chip formation

Experimental tests have shown that in severe working conditions, characterized by wide cutting depth intervals and low feeding rates per revolution, 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 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



Close tolerances on wall thickness

Thanks to the Diescher transverse rolling process and recent revamping of the Piercer mill, Tenaris is able to guarantee close tolerances, continually measured, as shown in the table on page 11.

Advantages

- Absence of unfinished areas, after mechanical working
- Reduction in weight of the initial tube

Straightness



The process controls make it possible to obtain a straightness equal or inferior to 1 0/00 cumulative on the entire length of the tube.

Advantages

- Better centering with subsequent reduction in chips to remove
- Lower vibration/oscillation inside the machine
- Reduction in machine stops
- Increased productivity

TAM® Plus

1. Applications

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

* HL = High machinability

2. Steel grades

CHEMICAL ANALYSIS %												
GRADE	C	Mn	Si	P	S	Ni	V	Cr	Mo	Al tot	Nb	Ti
E355 HL	≤ 0,20	≤ 1,50	≤ 0,50	≤ 0,030	0,020 - 0,035							
E470 HL	0,16 ÷ 0,22	1,30 ÷ 1,70	0,10 ÷ 0,50	≤ 0,030	0,020 - 0,035		0,08 ÷ 0,15			≥ 0,010	≤ 0,070	
E420J2 HL	0,16 ÷ 0,22	1,30 ÷ 1,70	0,10 ÷ 0,50	≤ 0,030	0,020 - 0,035	≤ 0,40	0,08 ÷ 0,15	≤ 0,30	≤ 0,80	≥ 0,010	≤ 0,070	≤ 0,050

* All the steel grades are completely calmed

Elements such as Al, Ti, Nb or V can be added for nitrogen fixation and to obtain the mechanical properties

MECHANICAL PROPERTIES: steel for mechanical fabrication														
GRADE	DELIVERY CONDITION*	TENSILE PROPERTIES										IMPACT TEST**		
		Rp02 (MPa) min					Rm (MPa) min					A % long.	Charpy KV long.	
		Wall thickness mm											min	T °C
		≤ 16	> 16 ≤ 40	> 40 ≤ 65	> 65 ≤ 80	> 80 ≤ 100	≤ 16	> 16 ≤ 40	> 40 ≤ 65	> 65 ≤ 100				
E355 HL	G	355	345	335	315	295	510-650	510-650	510-650	470	21	-	-	
E470 HL	G	470	430				650	650			17			
E420J2 HL	N	420	400	390	370	360	600	560	530	500	19	-20	27	

* G = as rolled (not treated) - N = normalized

Normalization can be done by normalization rolling carried out in a limited temperature range in order to develop the material to a state equivalent to that obtained after Normalization treatment.

The prescribed mechanical characteristics remain also after Normalization treatment

**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 KV_W value according to the formula: KV_W=KV₁₀ x (W/10)

Impact tests are not required for nominal wall thickness of <6mm.

3. Dimensional tolerances

Outside Diameter and Thickness tolerances are highlighted in the table.

Straightness: 1‰ cumulative

4. Lengths

Tubes are supplied in commercial lengths.

Option B

Different length to standard can be agreed upon at the time of ordering

Service Center

The Service Center can supply tubes cut in fixed lengths with tolerances of $-0 + 0,3$ mm

Squareness 1,5 mm

5. Checks

The product is subjected to the following tests:

- Mechanical tests in accordance with reference standards
- Electromagnetic test according to EN 10246-5 LIVF2
- Visual and dimensional check on each tube

Option C

Specific additional tests can be agreed at the time of ordering

6. Surfaces

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

7. Certification

The product is supplied with 3.1.B inspection certificate, in conformity with EN 10204

Tenaris employs complete product traceability.

8. Identification and marking

“TAM PLUS” mechanical tubes are identified as follows:

- Continuous paint marking (white colour):
 - . manufacturer's trade mark
 - . steel grade
 - . referring norme N°
 - . O.D. x WT
 - . S (production process)
 - . heat N°
 - . internal mill order N°
- Die stamping:
 - . manufacturer's trade mark
 - . TAM PLUS
 - . steel grade
 - . S (production process)
 - . plant inspector code N°
- PAINTING (pink colour)
 - . TAM PLUS (continuously all tube long)
 - . on cross sections of both tube ends

9. Packaging

In bundles fasted with strap.

Tenaris offers technical assistance for customized applications of its product.

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