Up to 0.10%Nb steels
help to increase

PIPELINE SAFETY

UP TO 0.10%Nb X80 API STEELS FOR COILS OR PLATES ALLOW DESIGNING PIPELINES WITH LARGER DIAMETERS FOR HIGHER GAS TRANSMISSION CAPACITY

As for example, using X80 with this chemistry and processing,

0.04% C – 0.10%Nb – 0.23%Cr **High Temperature Processed**

The following mechanical properties can be obtained

Yield strength σ_{ys} MPa	**Ultimate tensile strength σ_{uts} MPa**	**Elongation** (%)	σ_{ys}/σ_{uts}	**Uniform elongation** (%)
605	685	26	0.88	8.3

For a longitudinal pipe with 1,420 mm in diameter and 26.0 mm in thickness, it will be possible to sustain the pressures that can guarantee high gas transmission capacity without risk of failure:

Type of pressure	Barlow's equations	Calculated pressure
Burst (hydrostatic) pressure	$P_b = \sigma_{uts} \frac{2t}{D_0}$	25.0 MPa
Internal pressure at minimum yield	$P_{int} = \sigma_{ys} \frac{2t}{D_0}$	22.2 MPa
Maximum allowable pressure	$P_w = \sigma_{ys} \frac{2t}{D_0} F_d$	16.0 MPa

$D_0 = outside\ diameter; t = thickness; \sigma_{uts} = ultimate\ tensile\ strength; \ \sigma_{ys} = yield\ strength;$

$F_d = design\ fator = 0.72\ \ for\ a\ class\ 1\ pipeline$

Barlow's equation for pressure, based on the outside diameter, is commonly used in the pipeline industry. Burst pressure, internal pressure at minimum yield strength, and maximum allowable pressure are calculated using variations of this equation.

- Evaluation of burst pressure prediction models foe line pipes ,Xian-Kui Zhu & Brian N. Leis, International Journal of Pressure Vessels and Piping, 2011.
- Barlow's Formula – Internal, Allowable and Burting Pressure, https://www.engineeringtoolbox.com/barlow-d_1003.html

UP TO 0.10%Nb X80 STEEL WAS THE SOLUTION FOR LONG DISTANCE HIGH GAS TRANSMISSION CAPACITY PIPELINES IN

CHINA

The annual gas transmission increased from **15 bm3 to 38 bm3** by using higher diameter and wall thickness pipe and specifying X80 steel

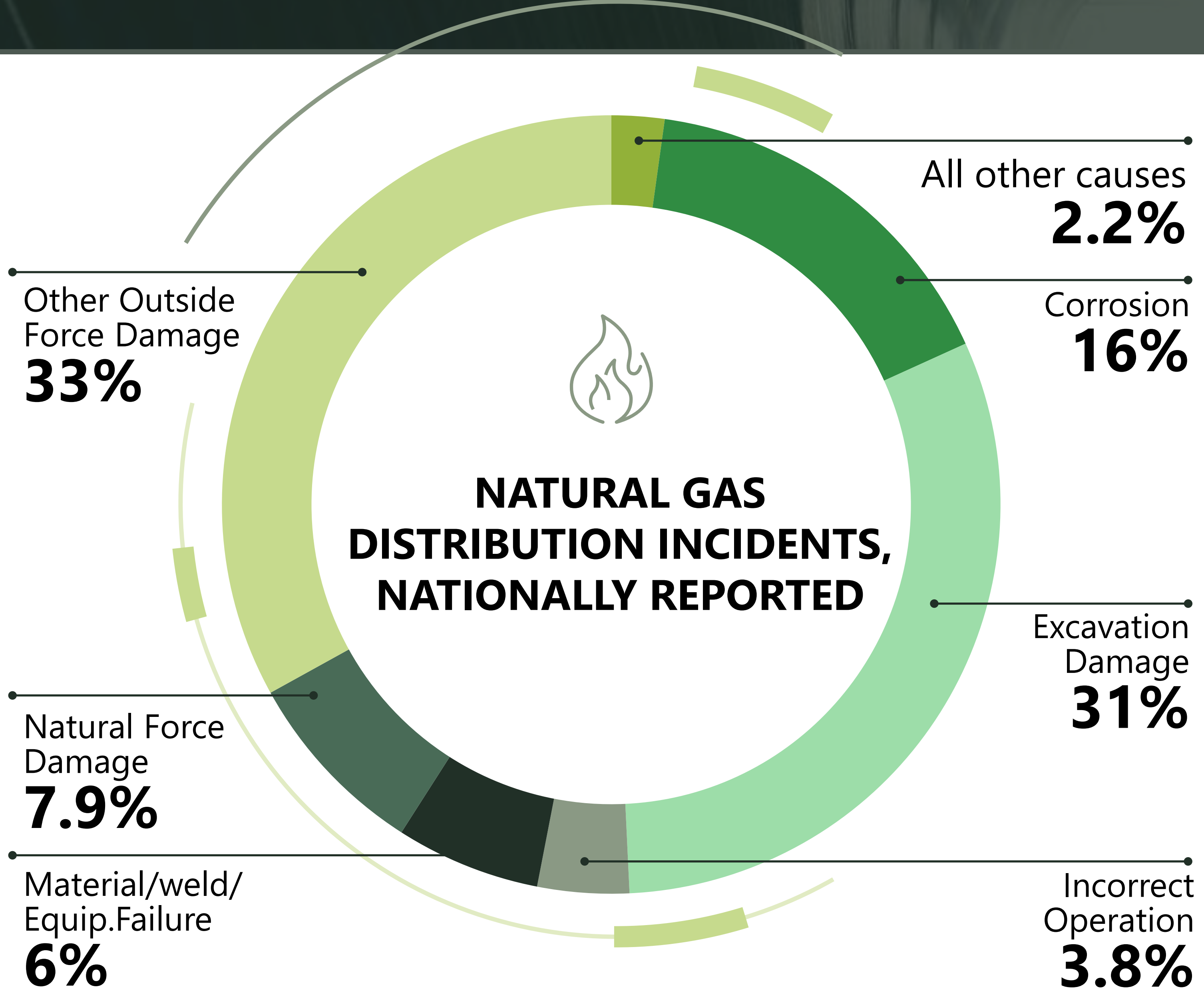
bm3 = billion cubic meter

Project	1st WEGP	2nd WEGP	3rd WEGP	R-CEGP
Construction period	2002 - 2004	2008-2012	2012	2017-2018
Steel grade/API	X70	X80	X80	X80
Diameter/mm	1016	1219	1219	1422
Maximum Working pressure/Pa	10	12	12	12
Wall thickness of spiral pipe/mm	14.7	18.4	18.4	22
Spiral pipe thickness/mm	18.4	22.4	22.4	26
Longitudinal pipe thickness/mm	4200	4895	7378	3170
Annual transmission capacity/bm3	15	30	30	38
Investment/billion RMB	140	142	120	-

• Shang, C., Guo, F. - The state of the art of long distance gas pipeline in China. https://www.gas-for-energy.com/fileadmin/G4E/pdf_Datein/g4e_1_18/gfe1_18_fb_ShangGuo.pdf

SAFETY OF PIPELINES DEPENDS ON MANY VARIABLES, AS SHOWN BY THE STATISTICS OF

INCIDENTS



https://www.gasfoundation.org/wp-content/uploads/2019/10/pipelinesafety.pdf

Of course, the base material and the welds **must meet all acceptance criteria for each project.**

16%

of the failures resulted from corrosion. Coating and cathodic protection are applied to mitigate these failures. Inspection and continuous maintenance are crucial for the safety of pipelines.

64%

are caused by mechanical damage. Damage can occur inadvertently during pipeline construction and operation and the best protection against catastrophic failure is high mechanical resistance and toughness. Good mechanical properties improve the resistance to damage from mechanical chocks during construction. Once the pipeline is pressurized, impact and abrasion can be the cause of failures that propagate for long distances making resistance to brittle fracture a key safety attribute.

Steels with up to 0.10%Nb are the best solution for pipelines combining

HIGH MECHANICAL STRENGTH WITH ENHANCED TOUGHNESS

C	Mn	Cu+Ni+Cr	Nb	Ti	N	Pcm
0.05%	1,55%	≤ 0.60%	0.095%	≤ 0.025%	≤ 0.008%	0.16

P and S maximums were 0.018% and 0.005% respectively

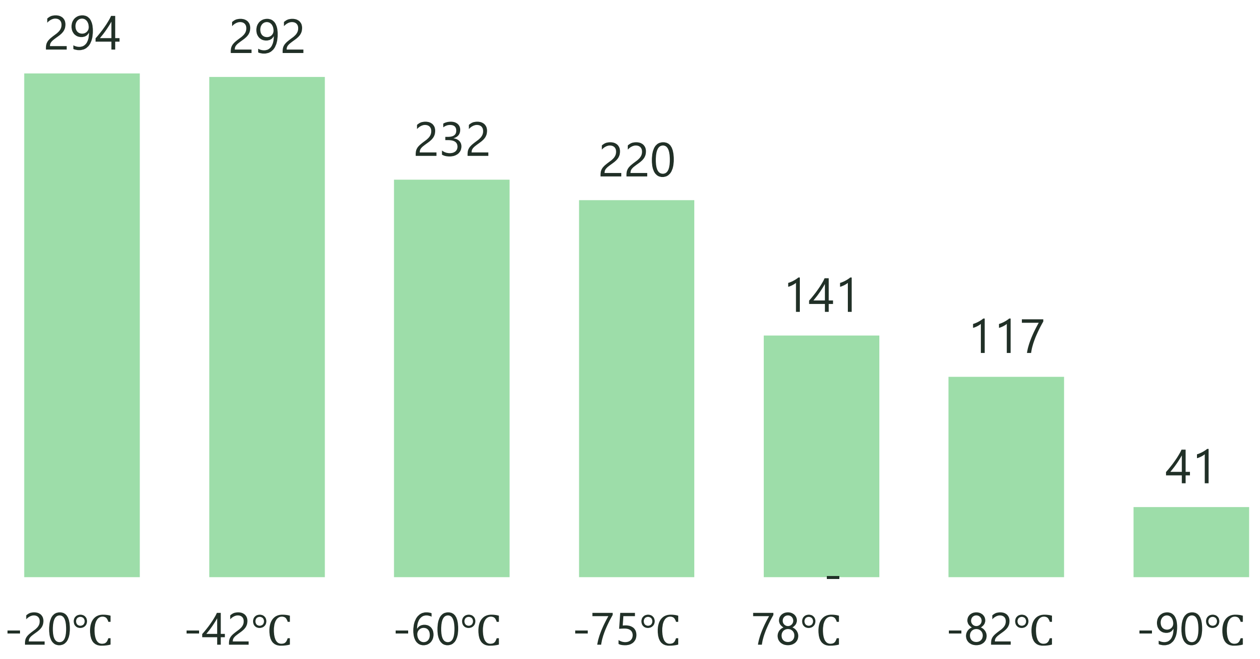
Direction	0,5% YS MPa	TS MPa	El %
L1	602	669	26.8
L2	604	663	25.2
Avg	603	666	26.0
T1	679	713	22.4
T2	682	708	23.6
Avg	681	711	23.0
X80 (Spec.)	555-705	625-825	

Specification of properties versus actual values for tests at -7ºC

	Base metal (J)	HAZ (J)	Weld (J)	DWTT
Specification	106	106	55	80%
Actual	292	290	80	100%

Example: Based on the steel used for the Cheyenne Plains Gas Pipeline, another pipeline 610km in length was built to transport natural gas from Colorado to Kansas and became operational in 2004. The X80 plates were from 12 to 17 mm in thickness and supplied by Oregon Steel Mills. These plates were transformed at Napa Pipe using the UOE process and which incorporates Double Submerged Arc Welding (DSAW) for the seam.

Subzero impact energy of base metal (J)

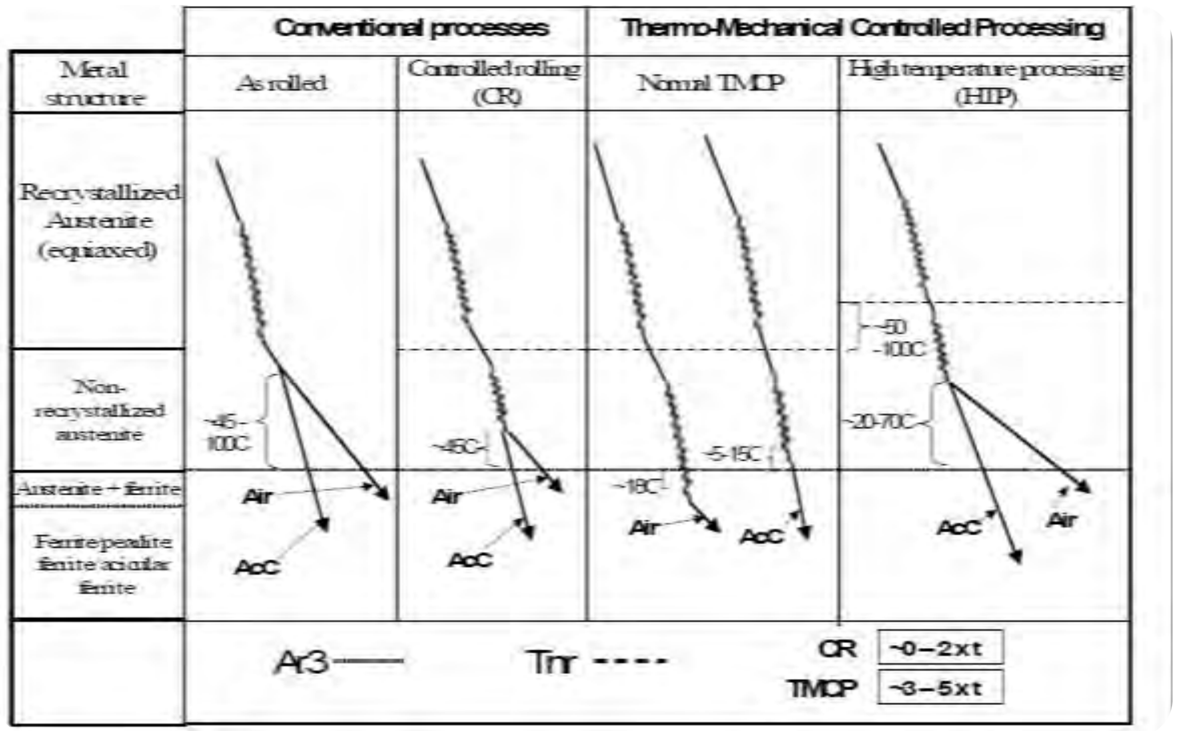


Douglas G. Stalheim, The use of high temperature Processing (HTP) Steel for High Strength Oil and Gas Transmission Pipeline Applications, Research Gate

Pyshmintsev, I. -Examination of microstructure, mechanical properties, and nonlinear fracture behavior of high-strength HTP linepipe steels, Characterization report, ROSNITI, Russia, 2012.

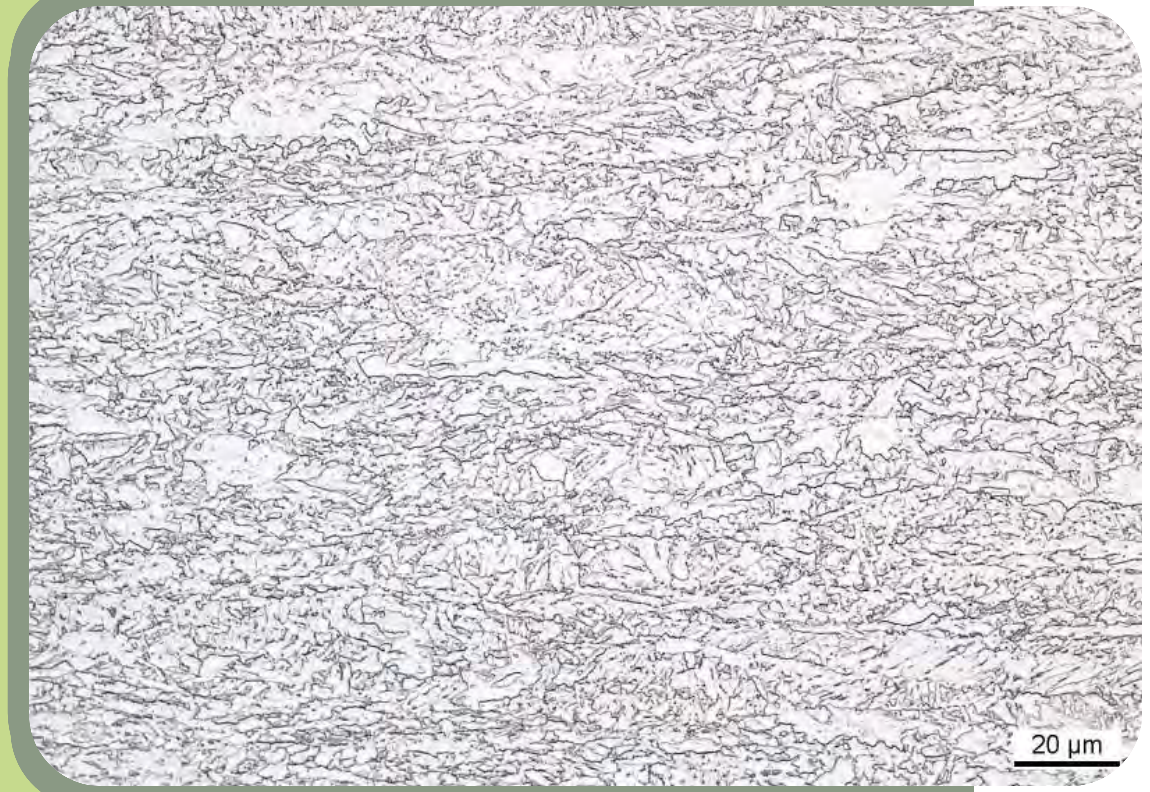
The use of niobium up to 0.10% in API steel **allows for TMCP rolling at higher finishing temperatures**. The higher finishing temperature improves the plate/coil production process achieving excellent cross-sectional microstructure, resulting in

OPTIMUM MECHANICAL PROPERTIES



Niobium increases Tnr temperature, hence retarding recrystallization, allowing hot rolling at higher temperatures without the risk of recrystallizing and growing the deformed grains. The result is a homogeneous and fine austenitic grain size and an austenite with more strain accumulation at the end of the hot rolling process.

D. G. Stalheim; K.R.Barnes; D.B.McCutcheon – Alloy designs for high strength oil and gas transmission linepipe steels, International Symposium on Microalloyed Steels for the Oil and Gas Industry, TMS, 2007.



Acicular ferrite, bainite and carbide precipitates

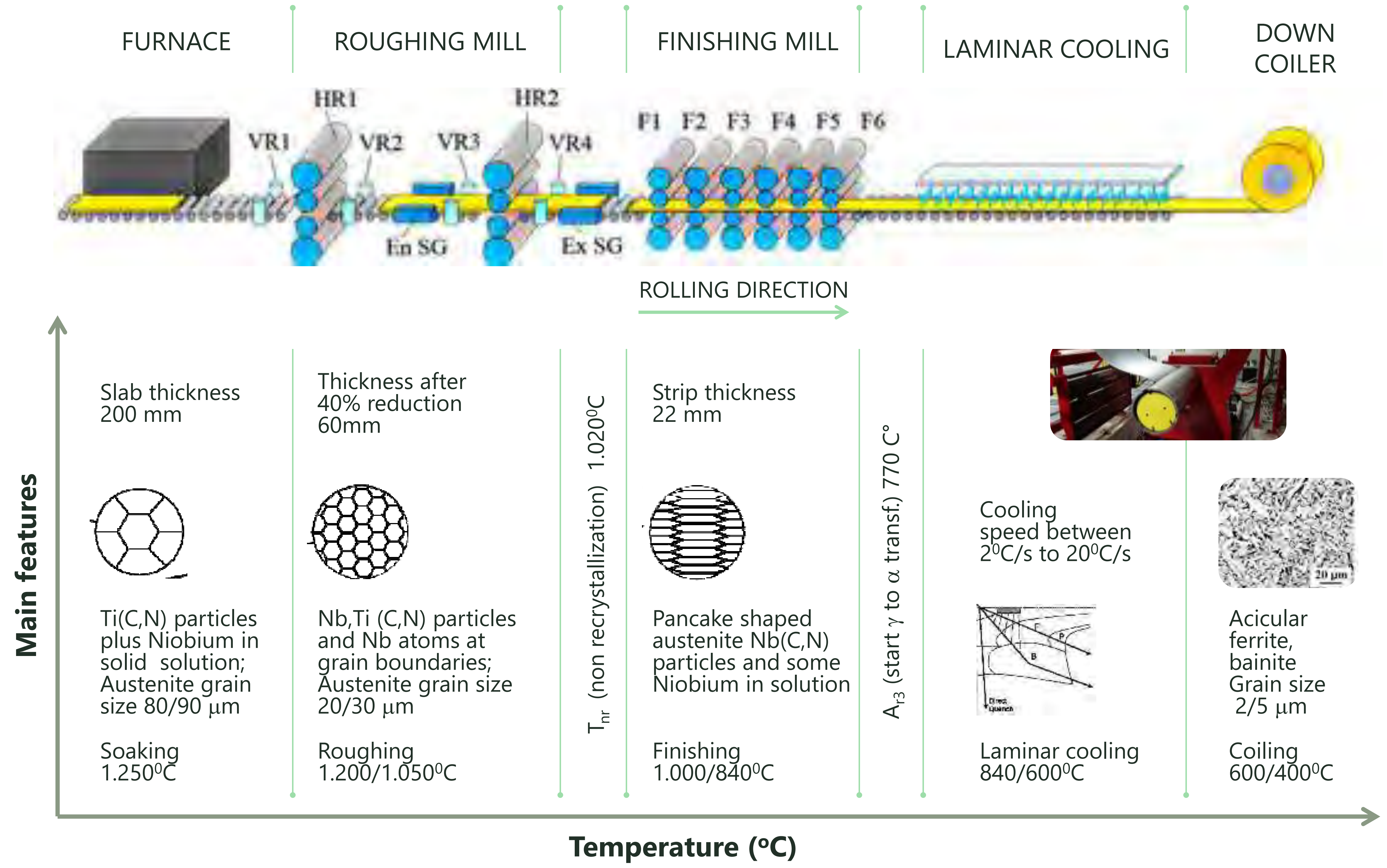
Finer and deformed austenite (higher strain accumulation) transforms into finer, more desired API microstructures compared to when austenite recrystallizes and grows during rolling

Volker Flaxa, Franz M.Knoop - Hot-rolled strips of up to 19 mm in thickness and their processing to helically welded large diameter pipes of grade X80, BAC2010, China, 2010.

Higher hot rolling temperatures provide

FINER AND HOMOGENEOUS GRAIN SIZE

Illustration based on the concepts presented by:
Han-Kai Hsu and Jong-Ning Aoh, The Mechanism of Position-Mode Side Guide in Correcting Camber in Roughing Process of a Hot Strip Mill, https://www.mdpi.com/2075-4701/9/5/504/htm



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Further information can be obtained at www.niobium.tech/energy

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