

toughcore®



Go beyond limits

Heavy plates tough to the core

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www.voestalpine.com/toughcore

voestalpine

ONE STEP AHEAD.

A large offshore oil rig is shown in the middle of a stormy sea with dark, heavy clouds. The rig is illuminated with lights, and its complex structure of pipes, cranes, and platforms is visible. The water is turbulent with white foam from the waves.

For extreme applications

toughcore®
Go beyond limits

Outstanding toughness to the core

toughcore® heavy plates provide outstanding toughness even to the core for very challenging operating conditions such as those at very low temperatures and in the ultra-deep sea.

toughcore® heavy plates create higher safety standards and enhance the potential for the use of heavy plates in linepipe applications, offshore structures, LNG and LPG, penstocks, cranes and equipment in the mining industry.

Unique advantages for your business

- Higher levels of safety
- Exploration of extreme regions
- Cost savings
- Increased productivity
- Best weldability

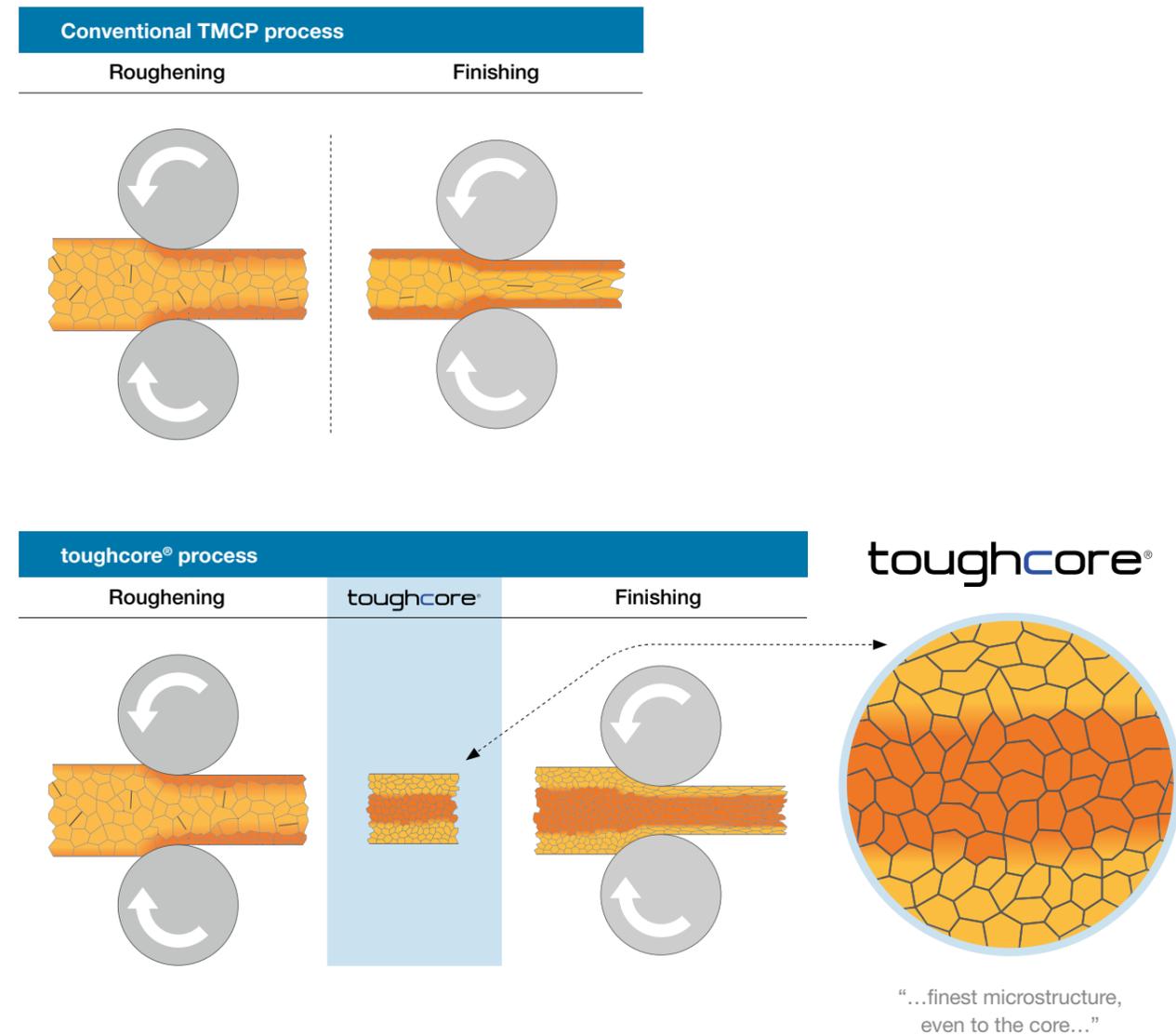
Tough to the core

Finest microstructure throughout the entire cross-section

toughcore® heavy plates are characterized by their extremely high toughness even to the core as a result of their remarkably fine microstructure throughout the entire cross-section. The microstructure is refined even in half plate thickness by accelerated cooling and consecutive fast reheating during the rolling process.

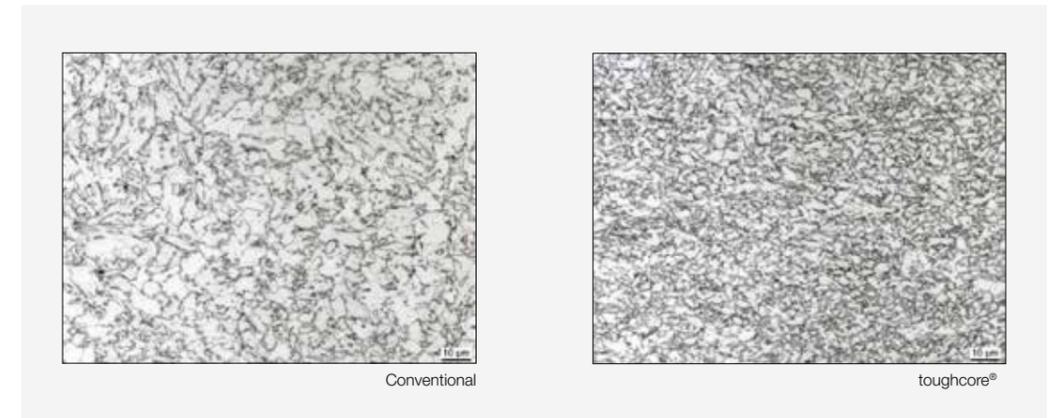
Our new generation of thermomechanically rolled (TMCP) steel is manufactured in a completely new and patented process that enables unique combinations of properties with respect to thickness, strength, excellent toughness and best weldability.

Conventional TMCP process compared to the toughcore® process



Comparison of conventional and toughcore® microstructure

Analysis of microstructure in half thickness, grade X80, t=50 mm



Unique advantages for your business

The outstanding toughness of toughcore® heavy plates result in higher levels of safety and the possibility of exploring extreme regions where conventional steels reach their limits. By choosing the best steel grades with the optimal dimensions for your specific application, you will benefit from better weldability, increased productivity and subsequent cost savings.



Higher safety levels

toughcore® steels are characterized by outstanding toughness (CVN, CTOD and Battelle) to the core, even at very low temperatures and for the largest plate thicknesses. Based on the significantly lower transition temperature of ductile to brittle fracture, applications can be achieved with substantially lower risk of brittle fracture. Even the heat-affected zone (HAZ) of welded structures features improved toughness to ensure the highest safety standards.



Exploration of extreme regions

Utilizing the full potential of toughcore® steels, you will step beyond current limitations and explore new environments such as extremely low arctic temperature regions and highest pressures in the ultra-deep sea. Together we can realize fixed and floating offshore structures, pipelines, cranes and mining equipment under extreme application conditions.

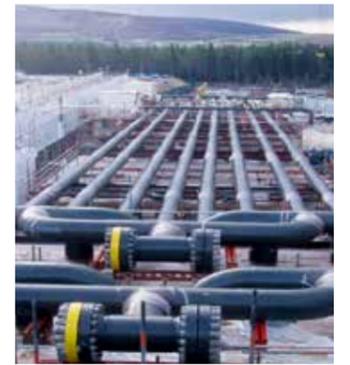


Cost savings

High-strength toughcore® plates are available in a higher thickness range and with superior toughness when compared to conventional products and can be used in lightweight applications in the offshore and linepipe industry and thus save costs in manufacturing, transportation and installation. As a result of their extreme toughness, even at very low temperatures, expensive nickel steel plates can be replaced with cost-efficient toughcore® TMCP heavy plates.

Increased productivity

Increase your productivity with the right choice of material or optimized component design. toughcore® remains fine-grained in the heat-affected zone (HAZ) of the welded joint and therefore sufficiently tough to meet existing requirements, even after highly productive welding with higher heat input. Thick-walled toughcore® heavy plates enable larger diameter of pipes, maximizing pipeline flow rates as well as slug catcher capacities.



Best weldability

toughcore® high-strength TMCP heavy plates with higher thickness and excellent toughness cannot be manufactured in any other production process. Penstock or machinery applications that require quenched and tempered (QT) steel can now be substituted by toughcore® TMCP steel. Benefiting from the lower carbon content and the lower sensitivity to cold cracking, TMCP steel can be welded without preheating, at a lower rate of failure and with higher heat input.





Outstanding properties of the plate and in the welded joint

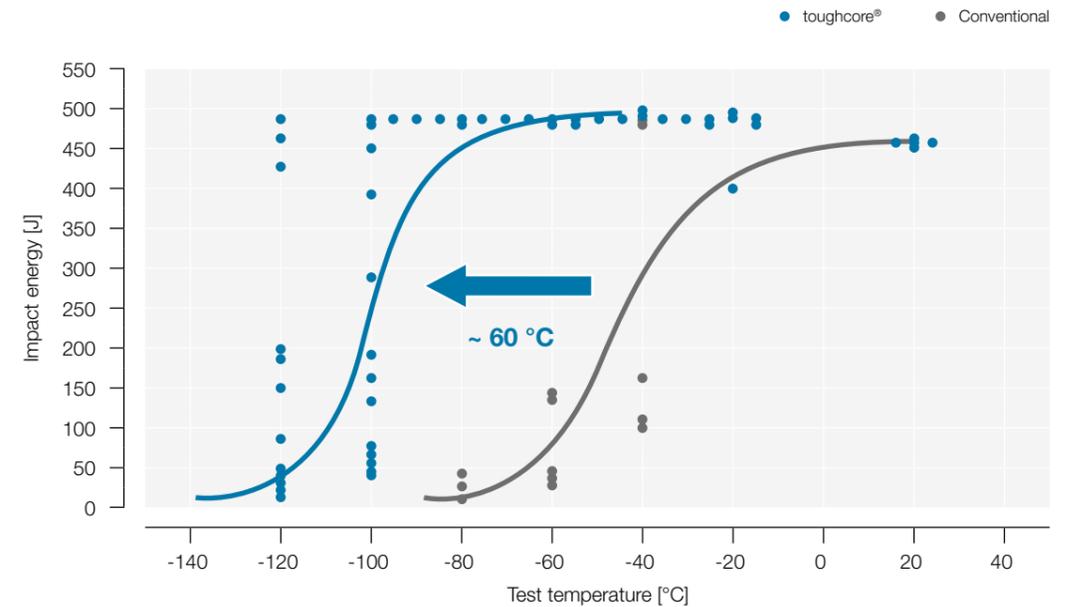
The unique microstructure of toughcore® heavy plates result in superior toughness properties of CVN, CTOD and Battelle, which cannot be produced in any other production route in the world. These outstanding properties in combination with highest producible material thicknesses facilitate the exploration of remote areas at very low temperatures and in the ultra-deep sea and ensure the highest safety levels.

Charpy V-notch toughness (CVN)*

Shrinking oil and gas deposits have shifted exploration to more remote areas. Materials used at extremely low arctic temperatures or extreme pressures in the ultra-deep sea call for excellent material properties in order to ensure the highest safety levels in structures and machinery. Our toughcore® heavy plates fulfill even the most stringent CVN requirements down to -100 °C.

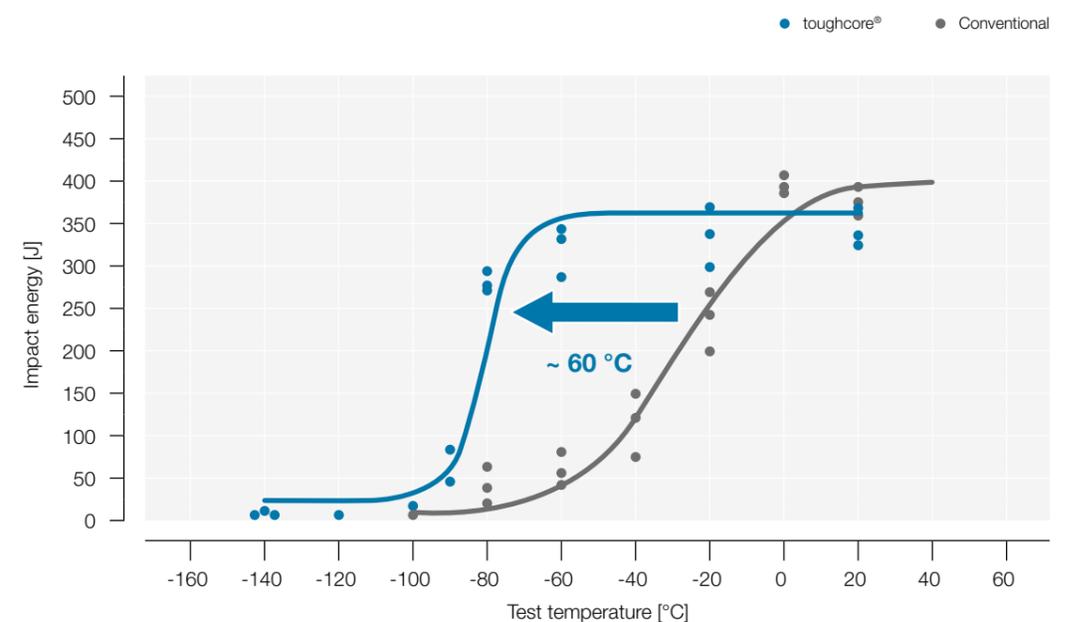
Charpy V-notch toughness (CVN) of plate

Comparison of conventional and toughcore® test values, X80, t=50 mm



Charpy V-notch toughness (CVN) of longitudinally welded pipe

Comparison of conventional and toughcore® test values in ½ thickness, fusion line, X80, t=50 mm



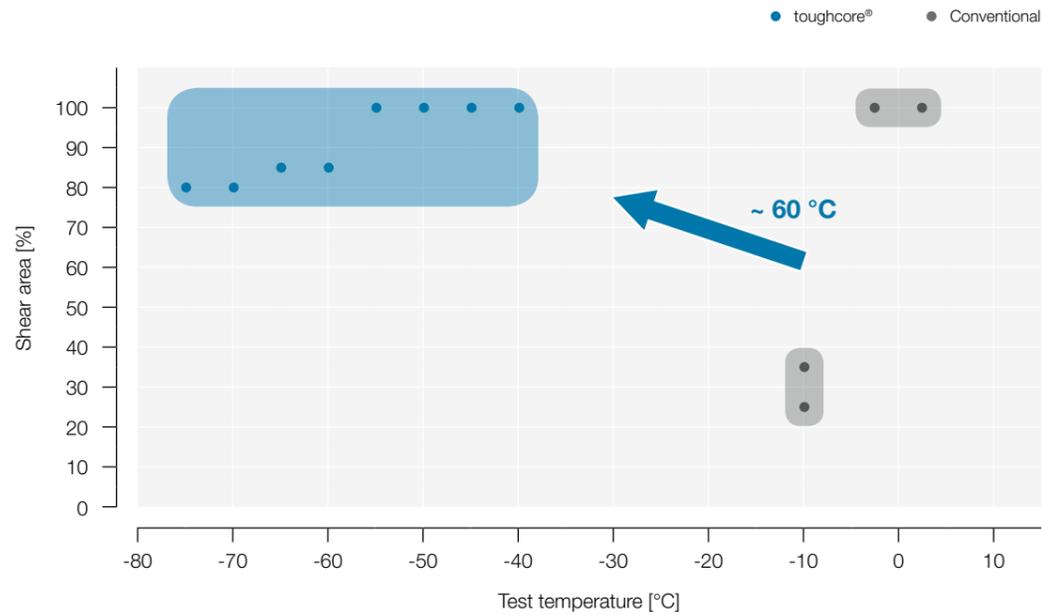
*) Typical values for grade X80 in thickness 50 mm

Battelle drop-weight tear test (BDWTT)*

The unique microstructure of toughcore® is characterized by extreme values of toughness even at very low temperatures, leading to an exceptional high ductile fraction ratio. A ductile fraction ratio of 85% down to -60 °C can be achieved with toughcore®, an advancement that increases safety levels in applications such as offshore platforms and penstocks.

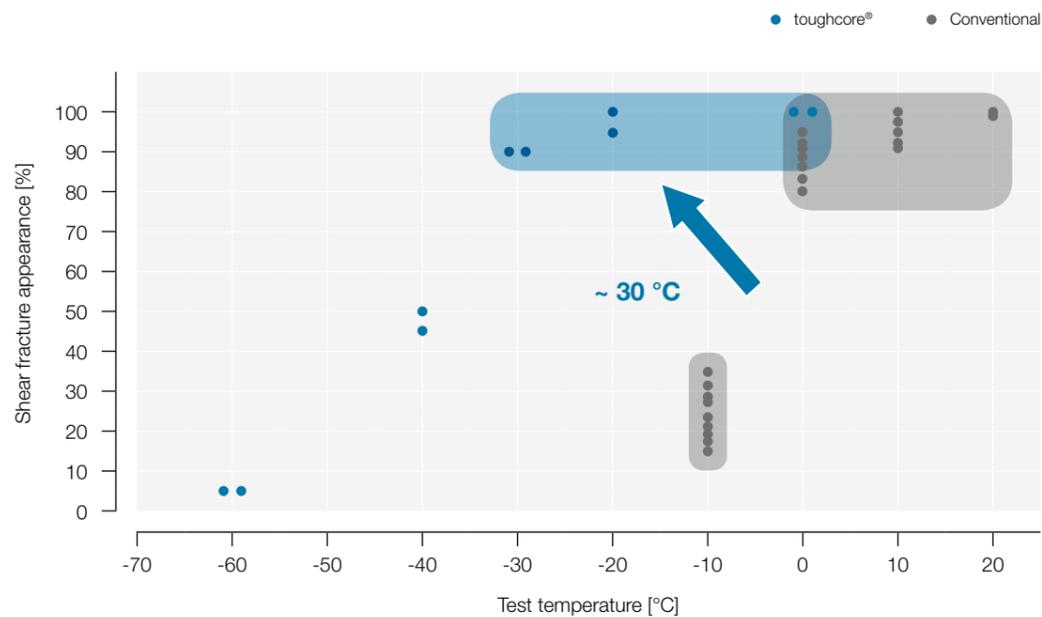
Battelle drop-weight tear test (BDWTT) of plate

Comparison of conventional and toughcore® test values, X80, t=50 mm



Battelle drop-weight tear test (BDWTT) of pipe body

Comparison of conventional and toughcore® test values, X80, t=50 mm

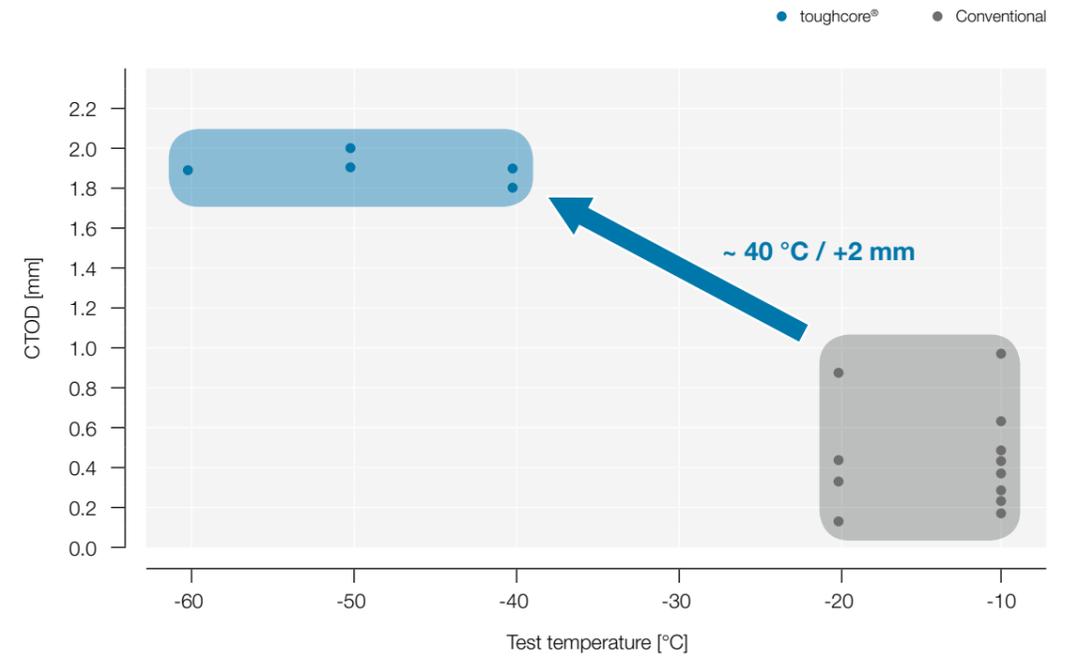


Crack tip opening displacement (CTOD)*

More and more offshore platforms or floaters are operated in Arctic regions where structures are exposed to extremely low temperatures and ice loads and face collisions with icebergs. We supply toughcore® heavy plates with outstanding CTOD values up to 2 mm, even at temperatures down to -60 °C and guarantee the highest level of operational safety.

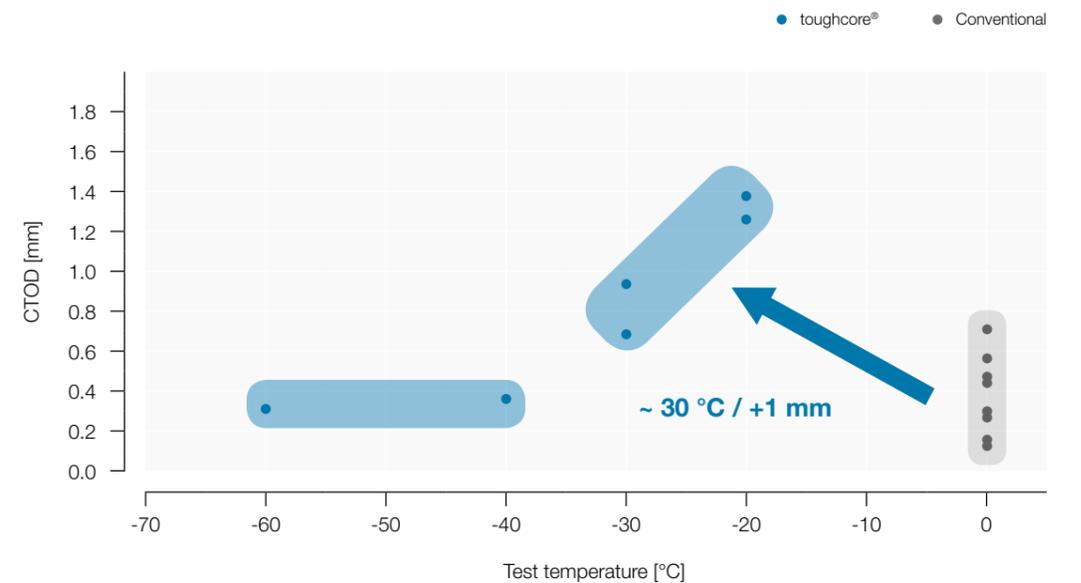
Crack tip opening displacement (CTOD) of plate

Comparison of conventional and toughcore® test values, X80, t=50 mm



Crack tip opening displacement (CTOD) of longitudinally welded pipe

Comparison of conventional and toughcore® test values, fusion line, X80, t=50 mm



*) Typical values for grade X80 in thickness 50 mm

Revolution
changes everything.
Especially
your business.

Innovative products for new applications

Having chosen toughcore® heavy plates for your application, you will benefit from increased safety, higher productivity, best weldability, cost savings and the possibility of exploring extreme regions where current materials are limited. voestalpine Grobblech GmbH is able to supply tailored products such as offshore plates, linepipe plates, plates for the energy storage and transportation as well as construction and machinery industries in order to open up new potentials for your business.



Innovative products for your application

Application	Offshore platforms		Linepipe			Energy storage and transportation		Construction and machinery industries	
	Offshore steel	Linepipe steel	Clad linepipe	Penstock steel	Nickel steel	High-strengths steel	Wear-resistant steel		
Higher CVN toughness on the plate	●	●	●	●	●	●	●	●	●
Higher CVN toughness in the HAZ	●	●	●	●		●		●	●
Higher CTOD values	●	●	●						
Higher battelle values		●							

Improved thickness related properties

Motivation to choose toughcore®

Motivation	Safety	Extreme regions	Cost reduction	Productivity	Weldability
Higher CVN toughness on the plate	●	●	●	●	●
Higher CVN toughness in the HAZ	●	●	●	●	
Higher CTOD values	●	●			
Higher battelle values	●	●			

Improved thickness related properties



Customized solutions for your business

Extremely low arctic temperatures, highest pressures in the ultra-deep sea or the most stringent requirements on toughness, strength and plate thickness: toughcore® is the answer to the most adverse conditions. Together we meet the demands of highly complex applications and push the limits toward new dimensions in the linepipe, offshore, energy storage and transportation as well as construction and machinery industries.

Linepipe

- Higher levels of operational safety
- Increased capacity of pipeline and auxiliary equipment
- Optimized manufacturing processes
- High strength for decreased weight and cost
- Linepipe plates for extremely low temperatures and the ultra-deep sea

Offshore

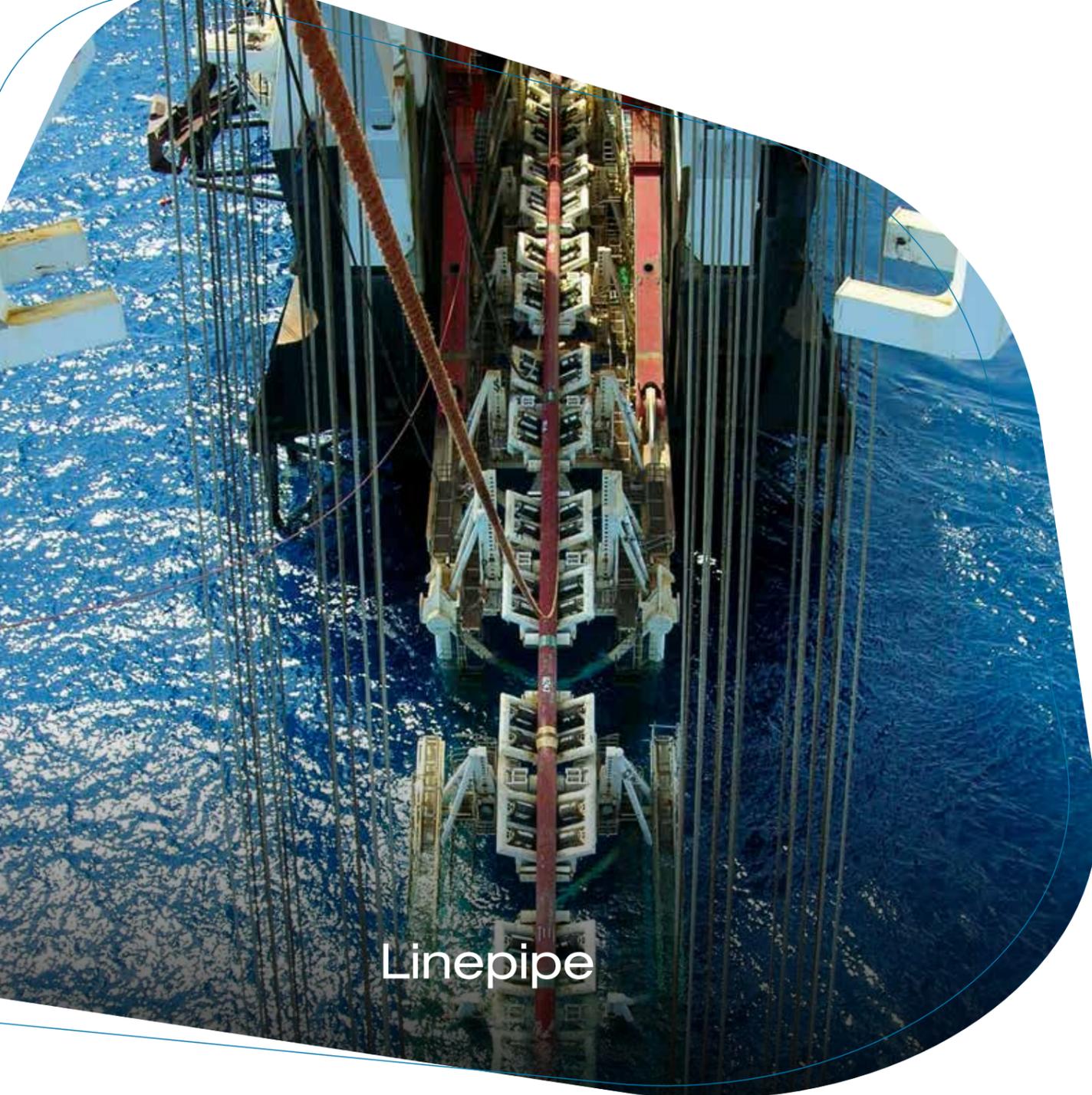
- Protect arctic offshore structures against ice loads and collisions
- Optimize the design of components and structures
- Light-weight design to reduce cost of manufacturing, transportation and installation
- Explore harshest environments

Energy storage and transportation

- Benefit from best weldability by choosing toughcore® TMCP plates instead of QT material
- Reduce costs by replacing expensive Nickel steel with toughcore® TMCP plates

Construction and machinery industries

- Used in structures and machines at very low application temperatures
- Benefit from the superior weldability of toughcore® TMCP plates as compared to QT material



Linepipe

Operational safety

When laying an offshore pipeline in the ultra-deep sea, the pipeline is exposed to a high level of stress caused by the laying process and extreme pressures in the ultra-deep ocean. Using the unique toughcore® process, high-strength plates with significant higher wall thickness can be produced as compared to conventional material. toughcore® buckle arrestors with an increased wall thickness and high resistance against buckling avoid the buckling of your pipeline even in the ultra-deep sea.

To avoid a long-distance cracking in onshore pipelines, crack arrestors with a high wall thickness and a high toughness must be installed at defined intervals. The toughness of thick plates that utilize toughcore® technology are increased even at very low temperatures. High toughness crack arrestors made of toughcore® plates reliably stop cracking, even at very low temperatures.

Higher productivity

The capacity of a pipeline and the related auxiliary equipment such as the slug catcher is determined by the cross-section and the moving speed of the media within the system. Thicker walled pipelines and equipment can be used to increase the diameter of the pipes and to withstand the external pressure levels in the ultra-deep sea or internal pressure peaks during operation.

With a greater wall thickness at the same laying depth, the pipeline diameter can be increased, which results in a higher flowrate per strand.

toughcore® enables thicker base material of roll-bonded clad plates with excellent toughness properties even at very low temperatures. The dimensions of the slug catcher can be increased for higher flow rates and in order to withstand higher pressure peaks, even in arctic regions.

Manufacturing efficiency

The remarkable microstructure of toughcore® base material remains fine-grained and therefore tough in the HAZ, even after welding with high heat input. Higher heat input can be subsequently applied during welding to meet existing toughness requirements. Welding costs can be reduced, and lower cycle times open up new potentials.

Reduced cost

toughcore® allows the production of pipe grades with higher tensile strength and high toughness at a thickness not achievable until now. Pipelines made of steel with higher tensile strength can be realized with a smaller wall thickness and therefore lighter weight when compared to conventional material. Such pipelines can be manufactured, transported and laid at substantially lower cost.

Extreme conditions

To avoid the brittle fracture of a component, the respective part must be operated at a minimum design temperature, which is above the transition temperature. Using toughcore® and its significantly lowered transition temperature, projects e.g. in arctic regions, Alaska or Siberia can be realized at lower temperatures without the risk of a brittle fracture.

Higher wall thicknesses can be produced using toughcore®, leading to a higher permissible buckling pressure and greater possible laying depths. Deeper projects and shorter pipeline routing can be realized because detours due to extreme deep sections are not necessary.

Available dimensions

- toughcore® heavy plates up to X80 with 50 mm wall thickness and superior toughness properties down to - 80 °C
- High strength heavy plates up to X120
- Plate lengths up to 18,700 mm and weights up to 20 tons per plate



“...with increased wall thickness and high resistance to buckling...”



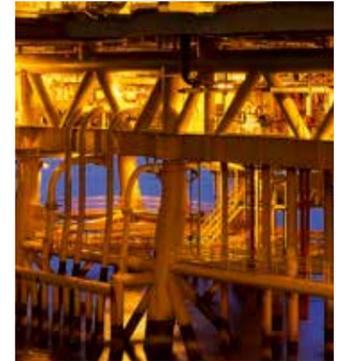
Offshore

Innovative design

Current jacket structures meet extraordinary requirements in X and K joints with regard to stress, buckling, yield strength and toughness. Current plate limitations allow a maximum component thickness of 100 mm in grade S420. The design of these components can be optimized with high-strength toughcore® for sufficient wall thickness and excellent toughness. This allows higher loads and increased safety levels.

Reduce weights

Larger offshore platforms and wider gaps between their columns require thicker material to avoid excessive deflection when using the same steel grade. This leads to an increase of the platform weight. On the other hand, the weight reduction of the topsides is an essential issue as heavier decks require larger buoyancy units to carry the loads, which again leads to increase cost. High-strength toughcore® plates with high wall thicknesses and excellent toughness are now available to optimize the design, lower the weight and reduce the cost (production, transportation and installation) of your platform while improving safety levels.



Example of cost reduction in tension leg platform (TLP)*

	Weight * \$/tons	Total cost approx.	Cost reduction per 1% reduction of weight
Topside	30,000 tons * 33,000 \$/tons	\$ 1 billion	\$ 10 million
Hull (2,200 m)	30,000 tons * 10,000 \$/tons	\$ 300 million	\$ 3 million
Tendons (2,200 m)	35,000 tons * 6,000 \$/tons	\$ 200 million	\$ 2 million
Total cost reduction per 1% reduction of weight			\$ 15 million

*) Assumed cost reduction per % reduction of weight

Explore harshest environment

The superb material properties of toughcore® and the finest microstructure throughout the entire cross section of thick plates guarantee highest safety levels during operation of offshore platforms and jackets, even at very low temperatures and in the exploration of frontier projects.

Protect the offshore structure

Offshore platforms and floaters located in arctic areas are exposed to extreme conditions with regard to CVN and CTOD due to ice loads and collisions with ice sheets or icebergs. This is why platforms and floaters are equipped with a reinforcement at the water line with thicker plates (up to 70 mm) with higher toughness – the so called "ice belt". toughcore® significantly improves toughness-related properties at very low temperatures and large wall thicknesses. Accidental collisions can occur with ships above and below the water line. The "ship collision zone" must feature extraordinary high material toughness (CVN) and withstand strain. In arctic areas, the ambient temperature is also very low, which leads to a worsening of this problem. Using toughcore® TMCP plates with extreme high toughness, you are able to increase the level of safety for your offshore structure, even at very low temperatures.

"...with extreme high toughness, you are able to increase the level of safety..."

Available dimensions

- toughcore® TMCP plates (e.g. S355 / S420 / S460) up to a thickness of 100 mm
- Outstanding toughness down to - 100 °C
- Plate widths up to 3,850 mm
- Plate lengths up to 18,700 mm
- Weights of up to 20 tons per plate



Energy storage and transportation

Best weldability

We are providing high-strength TMCP plates with higher thickness and excellent toughness, which is not producible with conventional thermomechanical rolling processes. Applications for penstocks which up to now required quenched and tempered (QT) steel can now be substituted by toughcore® TMCP steel. You will benefit from a lower sensitivity of cold cracking due to the low carbon content of TMCP steel compared to QT steel.

Customer benefits

- No or lower preheating
 - Reduction of manufacturing cost
- Reliable welding connection
 - Low rate of failure
- Higher heat input
 - Reduction of welding passes
 - Reduction of welding time
 - Reduction of welding cost

Reduced cost

The toughness and application temperature requirements are extraordinarily high in the storage and transportation of LNG and LPG.

- 3.5% Ni, 27/19J at -100 °C
- 5% Ni, 27/19J at -120 °C
- 9% Ni 50/40J at -196 °C

Providing this unique material properties, it is possible to substitute 3.5% or even 5% Nickel steel by toughcore® TMCP steels.

To fulfill the toughness requirements of a 9% Nickel steel with a lower Nickel content (e.g. 7% or even 5% Ni) it is possible to combine toughcore® technology with Nickel steel.

Using toughcore® instead of expensive Nickel steel or reducing the Nickel content in the analysis, while fulfilling the same mechanical and technological requirements, material cost will be reduced.

Available dimensions

- We deliver high-strength TMCP plates with excellent toughness for applications where up to now only QT steels were able to fulfill your requirements
- alform® plate 700M up to 100 mm with never seen toughness properties for arctic application and to increase the safety level
- alform® plate 960M x-treme up to 50 mm



“...with toughcore® no or lower preheating, more reliable welding connections and high heat input can be realized. We can deliver a steel that reduces welding passes, time and costs...”



Construction and machinery industries

Structures and machines for arctic regions

toughcore® provides finest microstructure throughout the entire cross-section. Therefore extreme toughness properties can be realized for thick plates, even to the core of the material and at very low temperatures.

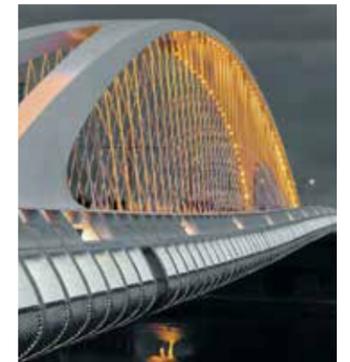
To avoid the brittle fracture of a component, the respective part must be operated at a minimum design temperature which is above the transition temperature. Using toughcore® the transition temperature will be lowered significantly. Cranes, trucks and mining equipment can be operated at, structures, buildings and bridges can be designed for lower temperatures e.g. in arctic regions, Alaska or Siberia without taking the risk of a brittle fracture.

Best weldability

Using toughcore® we are able to produce high-strength TMCP plates with higher thickness and excellent toughness, which is not producible with conventional thermomechanical rolling processes.

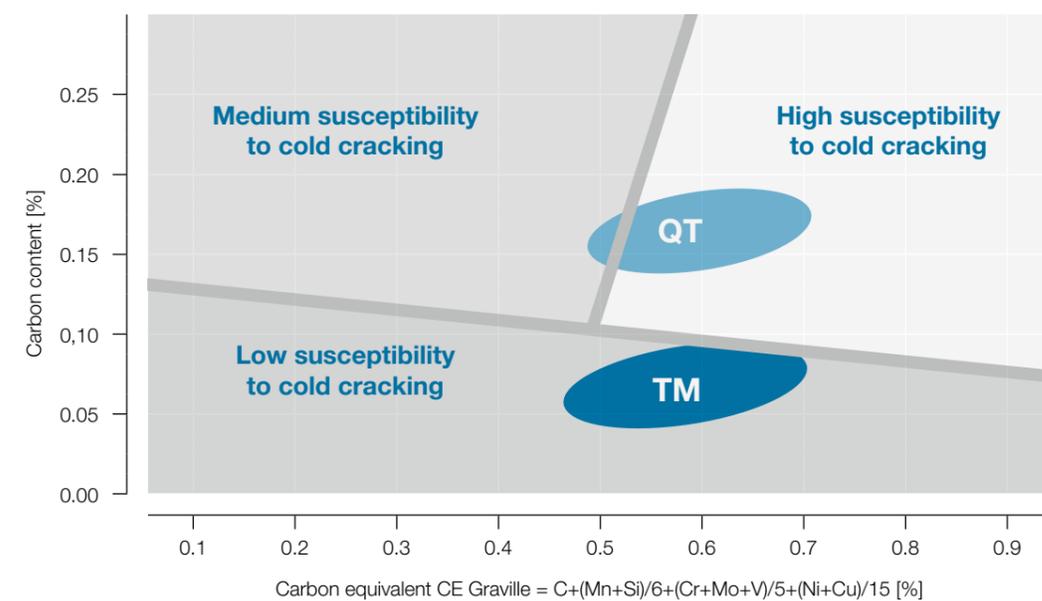
Applications for machinery industry which currently required QT steel can now be substituted by toughcore® TMCP steel.

Compared to QT steels, TMCP steels show a lower sensitivity of cold cracking due to the low carbon content. You will benefit from a lower sensitivity of cold cracking due to the low carbon content and better weldability of TMCP steel compared to QT steel.



Susceptibility to cold cracking

according to Graville



Available dimensions

- We deliver high-strength TMCP plates with excellent toughness for applications where up to now only QT steel was able to fulfill your requirements
- alform® plate 700M up to 100 mm with outstanding toughness properties, even for arctic application and / or to increase the safety level
- alform® plate 960M x-treme up to 50 mm

“...benefit from a lower sensitivity to cold cracking due to the low carbon content...”



As-delivered conditions

Declaration

toughcore® is a brand of voestalpine Grobblech GmbH and defines our new as-delivered condition of thermomechanically rolled heavy plates with unique combinations of thickness, strength, excellent toughness and best weldability.

Heavy plates delivered as toughcore® fully comply to all relevant standards in the linepipe, offshore, energy storage and transportation as well as construction and machinery industries.

The designation of the steel grade remains according to the respective standard. The declaration of toughcore® can be found as annexure to the as-delivered condition.

Examples of as-delivered condition toughcore®:

Standard	Linepipe	current	NEW
API 5L	Steel grade	X80	X80
	Delivery condition	TMCP	TMCP toughcore®

Standard	Offshore	current	NEW
EN 10025	Steel grade	S420 ML	S420 ML
	Delivery condition	TMCP	TMCP toughcore®

Standard	Machinery industry	current	NEW
voestalpine TTD	Steel grade	alform plate 700 M	alform plate 700 M
	Delivery condition	TMCP	TMCP toughcore®

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Technically more advanced. Successful together. voestalpine Steel Division – the partner you can trust.

High-quality materials are the basis for our products. We strive to be the best partner for our customers and want to provide them with the best-possible solutions. We focus our expertise on two aspects:

The personal aspect, with dedicated and highly competent employees
The technical aspect, with high-quality methods, products and services

The companies in the voestalpine Steel Division and their employees understand partnership to be the following

- Understanding for their customers' business
- Expertise and reliability
- Responsibility for satisfactory project completion
- Partnerships based on trust

Many years of successful partnerships with our customers prove our point.

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voestalpine

ONE STEP AHEAD.