

DILLIMAX & DILLIDUR

Ultra high strength and wear resistant plates

DILLINGER 

DILLINGER – A PASSION FOR STEEL

We have a passion for steel. For more than 330 years, we have put our trust in a wealth of ideas and innovations coupled with a love of detail and perfection.

The better the steel, the greater our customers' success

Steel is a unique and fascinating material, and those who understand and master it are rewarded with outstanding properties. At Dillinger, the entire production process – starting with research, and proceeding via steelmaking, up to and including the rolling mill – is focussed exclusively on our heavy plate product.

This specialisation has given rise to unparalleled know-how, exploited for the benefit of our customers. Knowledge, experience and the systematic use of ultra-modern AI applications enable Dillinger to produce even highly critical grades with certainty and to advance the development of challenging products. Whenever top quality, reliability and enhanced productivity are needed, Dillinger is there for you – and that's a promise!

Dillinger can supply an incomparable range of products, featuring more than 2,000 different grades of steel and an impressive spectrum of dimensions and formats. Carefully tailored advice for customers and, increasingly, a digital range of services provide an optimum conclusion to our products and activities.

Acclaimed throughout the world

The Øresund Bridge connecting Denmark and Sweden, Shanghai's World Financial Center, one of the world's tallest buildings, gigantic offshore wind-power facilities and drilling platforms, and the Louis Vuitton Museum in Paris, with its breathtaking architecture, are imposing examples of the diversity of the applications for Dillinger's high-tech steels, assuring the meeting of maximum standards and safety requirements.

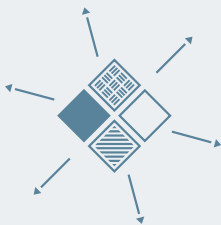
Our philosophy of sustainability

Steel is especially sustainable, like no other material, not least of all due to its extreme recyclability. Environmental protection, furthermore, is assigned special importance at Dillinger. The core feature of our sustainability strategy consists of low CO₂ steel production, environmentally safe products, continuous enhancement of energy-efficiency and resources conservation, the reduction of emissions and improvement of the environmental protection of water. Dillinger identifies with the aims of the Paris Climate Agreement. Our credo is: "Top-grade industrial technology coupled with sustainable management" – no more, no less.

DILLINGER AT A GLANCE

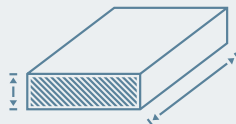
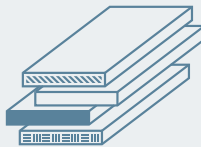


More than **330** years of experience in steel



Expert advice for more than
10 diverse fields of application

Over **2,000**
different grades



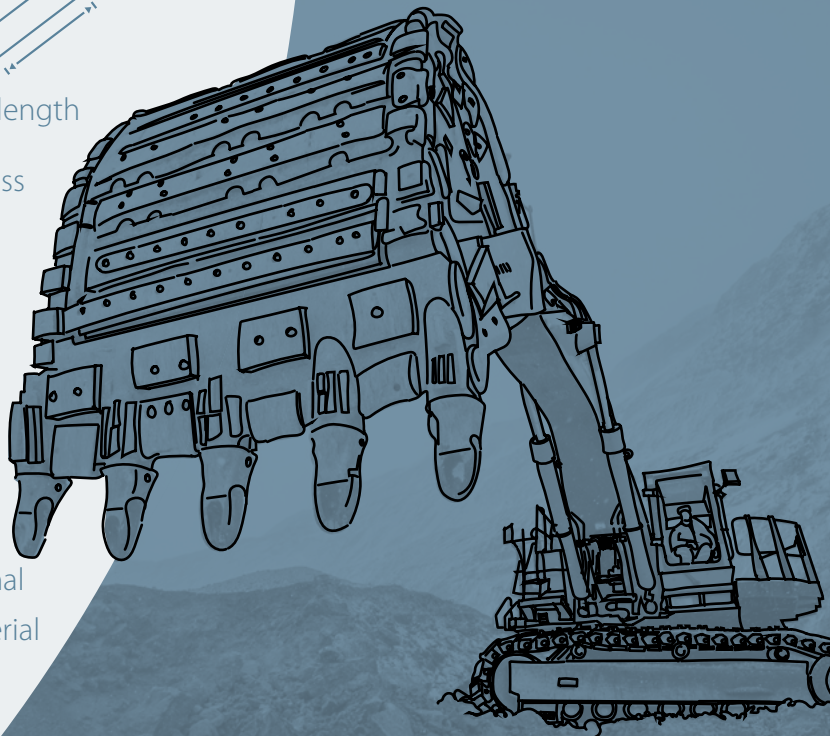
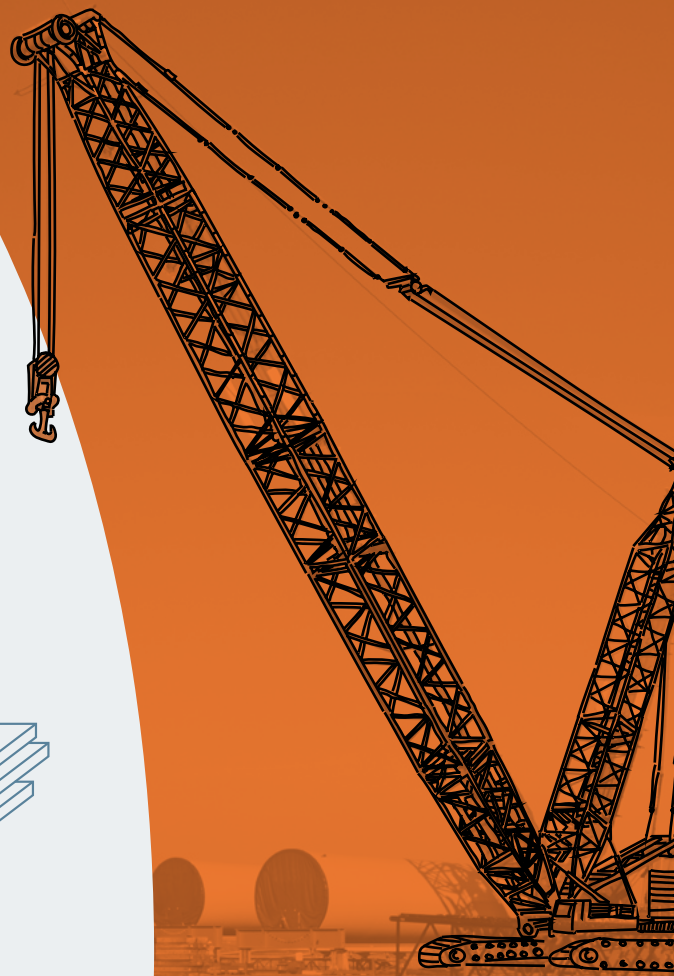
Heavy plates up to **28 m** length
and **500 mm** thickness

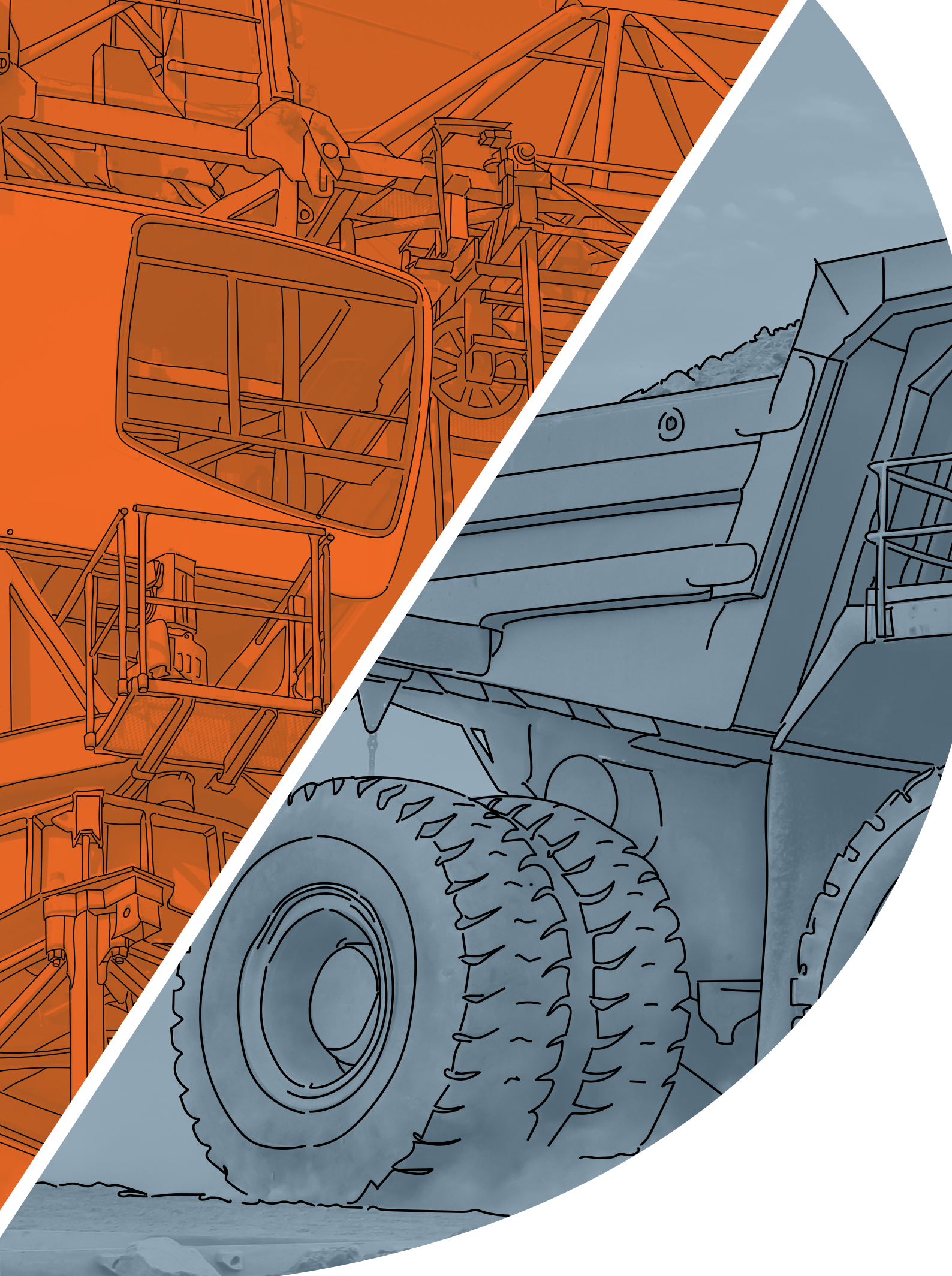


Plate weight up to **52 t**



More than **200** international
approvals, certificates and material
qualifications





DILLIMAX AND DILLIDUR – SPECIALISTS IN DIVERSITY

Top performance demands top materials. This was why DILLIMAX and DILLIDUR were originally created: for half a century, these specialists in ultra-heavy loads and rough abrasive wear have grown – with their applications and with our customers. Mechanical strengths and plate thicknesses have increased, cleanness and toughness have been refined. The result: More efficiency and maximum safety – a development that assures measurable added value.

Lightweight designs cut costs

Anyone aiming to conserve resources will need to save. Thinner and therefore lighter plates with elevated mechanical strengths are used to reduce the weight of moving parts. They also make fabrication more efficient: thinner and lighter designs can be achieved with smaller welds, consuming less welding time.

Demands for ever higher maximum loads

Lifting equipment and machinery used in mining have grown to a giant size. The forces arising here necessitate ever higher mechanical strengths, combined with exceptional plate thicknesses.

New potentials need greater safety

Precisely under difficult service conditions – such as the installation of offshore wind farms using giant cranes – the plates selected must meet extremely high standards for internal cleanness and resistance to fracture.

Your product benefits at a glance

DILLIMAX

- Ultra-high mechanical strengths, with yield strengths of up to 1100 MPa
- For ultra-high loads

DILLIDUR

- Hardnesses of 325 to 600 Brinell
- For maximum resistance to wear
- Broad range of grades
- Individually tailored specifications
- Extreme thicknesses
- Large dimensions and formats
- Extra-heavy precision-cut plates

Your service benefits at a glance

- The experience of our technical and commercial specialists assures comprehensive advice
- Fabrication services available
- Flexible delivery logistics



Discover our **E-Service** system: it's packed with useful tools and features, your own personal myE-Service area, providing all information on your orders, as well as the **E-Connect app** for plate identification.

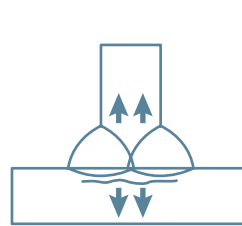
FROM A DREAM COMBINATION TO A UNIQUE MATERIAL

The foundation for the high-quality heavy plates produced by Dillinger is laid in our own steelmaking plant. This is where homogeneous feed material for DILLIMAX and DILLIDUR originates, after which the plate is rolled with the application of extraordinarily high forces and the use of ultra-smart technologies in the rolling mill. But only very special techniques and treatments make them into top-performance steels.

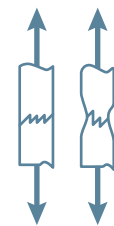
It all starts in the steelmaking plant

Anyone aiming to meet high safety standards needs plates of enormous toughness and extremely homogeneous properties. The so-called Z grades guarantee exactly that: the plate features special deformation properties in the thickness direction at the most challenging point, the plate centre. High strength DILLIMAX and wear resistant DILLIDUR steels are degassed under vacuum. This, in combination with sophisticated secondary metallurgy, reduces the amount of undesirable tramp elements, such as sulphur, for instance, to a minimum. A high-quality plate – especially in large plate thicknesses – necessitates sufficiently thick and especially homogenous feed material. Dillinger casts this steel, using the continuous-casting process, into so-called slabs of up to record thicknesses

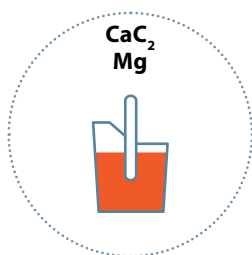
of 600 mm. A homogenous internal quality is assured at Dillinger as a standard feature: all DILLIMAX plates are delivered in accordance with ultrasonic class S₁E₁ - or to even more demanding customer specifications.



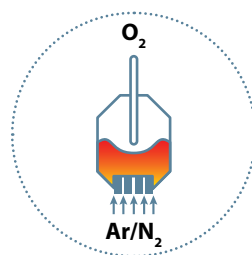
Stresses in the direction of plate thickness caused by welding



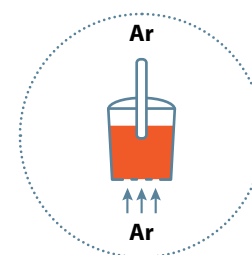
Z inspection: Assurance of the deformation capacity in the centre of the plate



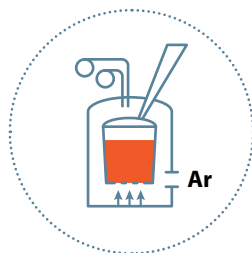
Hot-metal desulphurisation



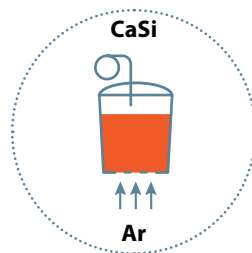
Oxygen top-blowing converter



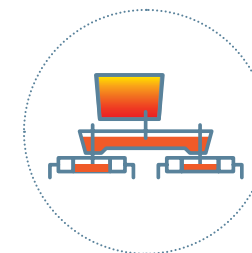
Argon bubbling process



Degassing process



CaSi treatment



Casting

Precision work in the rolling mill

Extraordinary forces act at the Dillinger plant: in the rolling process, the plate is rolled under forces of up to 108 MN (approx. 11,000 t) from the feed material, i.e. either a slab or an ingot. Rolling progresses in the largest possible "steps", so-called "rolling passes"; the rolling schedule, in other words, the temperature-dependant sequence of rolling passes, is decisive in this process. Thanks to this "high-shape rolling", not only the surface, but also the plate centre, is defined and the most homogenous possible plate is thus produced; the steel's remarkable mechanical strength or wear resistance is achieved in quenching and tempering apparatus. Extremely rapid cooling using water results in a hardened microstructure, distributed uniformly across the entire plate surface – and thus in the high wear resistance of the DILLIDUR 400 to 600 grades. In the case of DILLIMAX steels, this is followed by a fur-

ther heat-treatment operation, so-called tempering. The plate's microstructure is thus relaxed. At the same time, hardness and mechanical strength are adjusted to exactly the required values and toughness is raised to an extremely high level.

Individualised end product

Other production operations, such as marking, adjustment of exacting flatness requirements on the straightening presses and/or blasting and coating follow, depending on the customer's specifications. Our customers decide themselves what they need, such as temporary corrosion protection (shop primer), for instance; although often a good idea, to permit temporary storage of plates in the open air, primer may, on the other hand, sometimes simply not be desirable for technical reasons connected with welding processes.

Dependable safety: The Z grade

High stresses occur in the direction of the plate thickness in welded structures, even without subsection to load, as a result of the cooling and shrinking of deposited weld metal. The Z grades in accordance with EN 10164 and ASTM A770 bindingly specify mechanical properties in the plate thickness direction. Z 35 in accordance with EN 10164 indicates, for example, that a round specimen taken in the plate thickness direction necks-in by not less than 35% prior to fracture. This is achieved thanks to special treatment of the steel. This deformation capacity assures safety to the designer, because he is then able to specify the necessary Z grade for his design - on the basis of EN 1993-1-10, for instance.

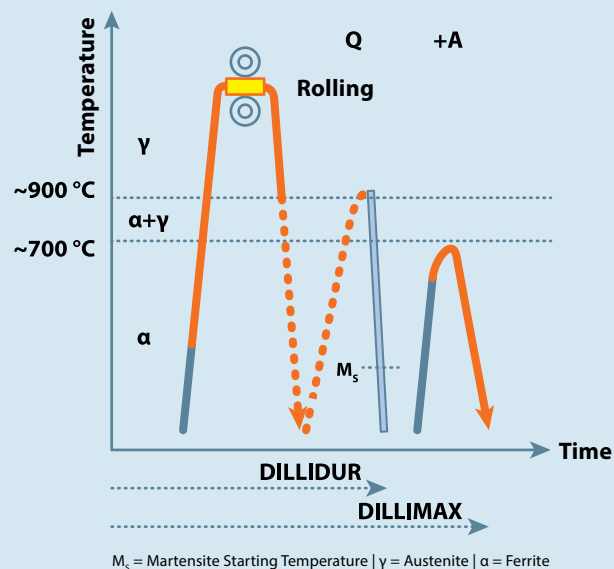
Tempering of DILLIDUR and DILLIMAX

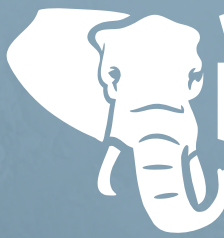
Quenching in water from the austenitisation temperature
($>A_{c3} \approx 900^\circ\text{C}$)

= Q (Quenched), e.g. DILLIDUR 500

+ additional tempering

= Q + A or Q + T (Quenched + Tempered),
e.g. DILLIMAX 965 E





DILLIDUR

HARD BUT SMART



DILLIDUR – WHEN HARD REALLY MEANS HARD

Hard in service, but easy to work – and therefore a success for more than 50 years. Wear resistant DILLIDUR steels combine ultra-high wear resistance with constant, simple and cost-efficient workability.

Used around the globe

DILLIDUR is convincing: Excavators, demolition and recycling equipment, as well as gigantic machines for recovery of mineral resources, are all equipped with Dillinger's wear resistant proprietary steel. A carefully tailored series of grades up to a hardness of 600 Brinell are available for our customers' specialised needs.

The basic DILLIDUR 400 grade is the convincing solution when easy workability combined with good wear resistance is needed. This grade, with its nominal hardness of 400 Brinell, is characterised by exceptionally low carbon contents and thus extremely good suitability for flame-cutting and welding, at economical low preheat temperatures - in fact, in many cases, with no cost-intensive preheating at all.

DILLIDUR 500, despite its very high nominal hardness of 500 Brinell and its extremely high wear resistance, can be safely and cost-efficiently further worked using Dillinger's processing notes.

Special applications

Air-hardened DILLIDUR 325 L, with a nominal hardness of 325 Brinell, is used in special applications involving more elevated temperatures of up to around 500 °C and for hot-formed wear parts. Thanks to the alloying concept used, this grade hardens automatically even under slow cooling in air. After normalising - e.g. for hot forming - the properties described in the data sheet are restored automatically.

Thick-walled and, in many cases, welded wear parts, such as the cutting edges of high-capacity shovels for service under adverse conditions in mines, need a special level of resistance to cracking. This is provided by DILLIDUR IMPACT: plate thicknesses of 40 mm to 150 mm with guaranteed Charpy V-notch toughness.

Special grades are available on request to permit the use of extremely large plate thicknesses combined with special requirements for plate-centre properties. The Dillinger range includes the two DILLIDUR 550 and DILLIDUR 600 grades for particularly challenging service conditions.

DILLIDUR	600/550	500	450	400	IMPACT	325 L
Abrasive wear	++++	+++	++	+	+	+
Weldability	-	0	+	+	++	-
Cold formability	-	0	+	+	+	--
Hot formability	-	-	-	-	0	+
Service at elevated temperatures	-	-	-	-	0	+
Resistance to cracking	-	0	+	+	++	-
Machining	0	0	+	+	+	+
Nitriding	-	-	-	-	+	+

Grade	Plate thickness [mm] (in.)	
DILLIDUR 600	15 - 60 (0.6 to 2.4)	560 to 610 HBW
DILLIDUR 550	10 - 100 (0.4 to 4)	500 (520) to 580 HBW (depending on thickness)
DILLIDUR 500 ^{a,b}	8 - 100 (0.3 to 4)	450 (470) to 530 HBW (depending on thickness)
DILLIDUR 450 ^{b,d}	6 - 100 (0.25 to 4)	420 to 480 HBW
DILLIDUR 400 ^{b,c,d}	6 - 150 (0.25 to 6)	370 to 430 HBW
DILLIDUR IMPACT	40 - 150 (1.6 to 6)	310 to 370 HBW, with enhanced crack resistance
DILLIDUR 325 L	6 - 100 (0.25 to 4)	Nominal hardness 325 HBW, air-hardened for elevated surface temperatures or hot forming

^a Also available as through-hardened variant DILLIDUR 500 T in thicknesses of 30 to 100 mm (1.2 to 4 in.)

^b Additional requirements on request

^c Also available as through-hardened variant DILLIDUR 400 T in thicknesses of 120 to 200 mm (4.8 to 8 in.)

^d Thickness < 8 mm (0.3 in.) upon request

DILLIMAX – HIGH EFFICIENCY MAKES SLENDER DESIGNS POSSIBLE

Extreme mechanical strength enhances design freedom: using DILLIMAX, the necessary plate thickness can be reduced to a minimum. The optimised steel analysis assures low carbon equivalents – and thus cost-efficiency: despite its high mechanical strength, DILLIMAX can be welded after application of only moderate preheat temperatures.

No limits on cost-efficient slender designs

Gigantic machines, conveying systems and lifting equipment are in continuous use around the world. They are designed to move maximum loads cost-effectively while, at the same time, having the lowest possible deadweight. Even when extremely thick plates are selected, ever greater mechanical strengths in the steels are needed for load-bearing designs. Exceptionally high toughness ratings, as a safety margin for use under extreme loads, are vital in thick-walled welded designs in particular, and are therefore mandatorily prescribed in codes, standards and specifications, such as EN 1993-1-10, for example. DILLIMAX, with its nominal yield strengths of up to 1100 MPa, exceeds the standardised requirements for mechanical strength - very significantly, in some cases – and with genuinely achievable toughness data well above the requirements of the standards, even at the ultra-low temperature of -60 °C. The grade designation, such as DILLIMAX 690 B/T/E indicates the nominal yield strength (690 MPa, in this case) and the temperature at which toughness requirements are guaranteed (Basic: -20 °C, Tough: -40 °C and Extra Tough: -60 °C). In the case of DILLIMAX 690 B/T, Dillinger guarantees 60 J/40 J (longitudinal/transverse), instead of the 30 J/27 J specified in the EN 10025, Part 6 standard. We are also always pleased to go beyond the limits defined in the standards and data

sheets for plate thickness and other plate dimensions. This is the case, for example, with DILLIMAX 965, which for special customer requirements can be supplied in thicknesses of up to 150 mm. This means: greater reserves of strength for the plate user at the design stage and during service.

Because every kilo counts

Only minimal thickness deviations can be tolerated in weight-sensitive applications, such as the telescopic booms of mobile cranes. For this reason, DILLIMAX TL assures correspondingly tight tolerances for thickness and flatness.

Every extra millimetre consumes expensive machining time and causes enormous additional costs for large machined components, as are needed in mechanical engineering. To reduce thickness allowances, DILLIMAX plates of up to 200 mm plate thickness can also be ordered in accordance with the DIPLAN specification. This assures flatness within extremely tight tolerance limits across the entire surface of the plate.

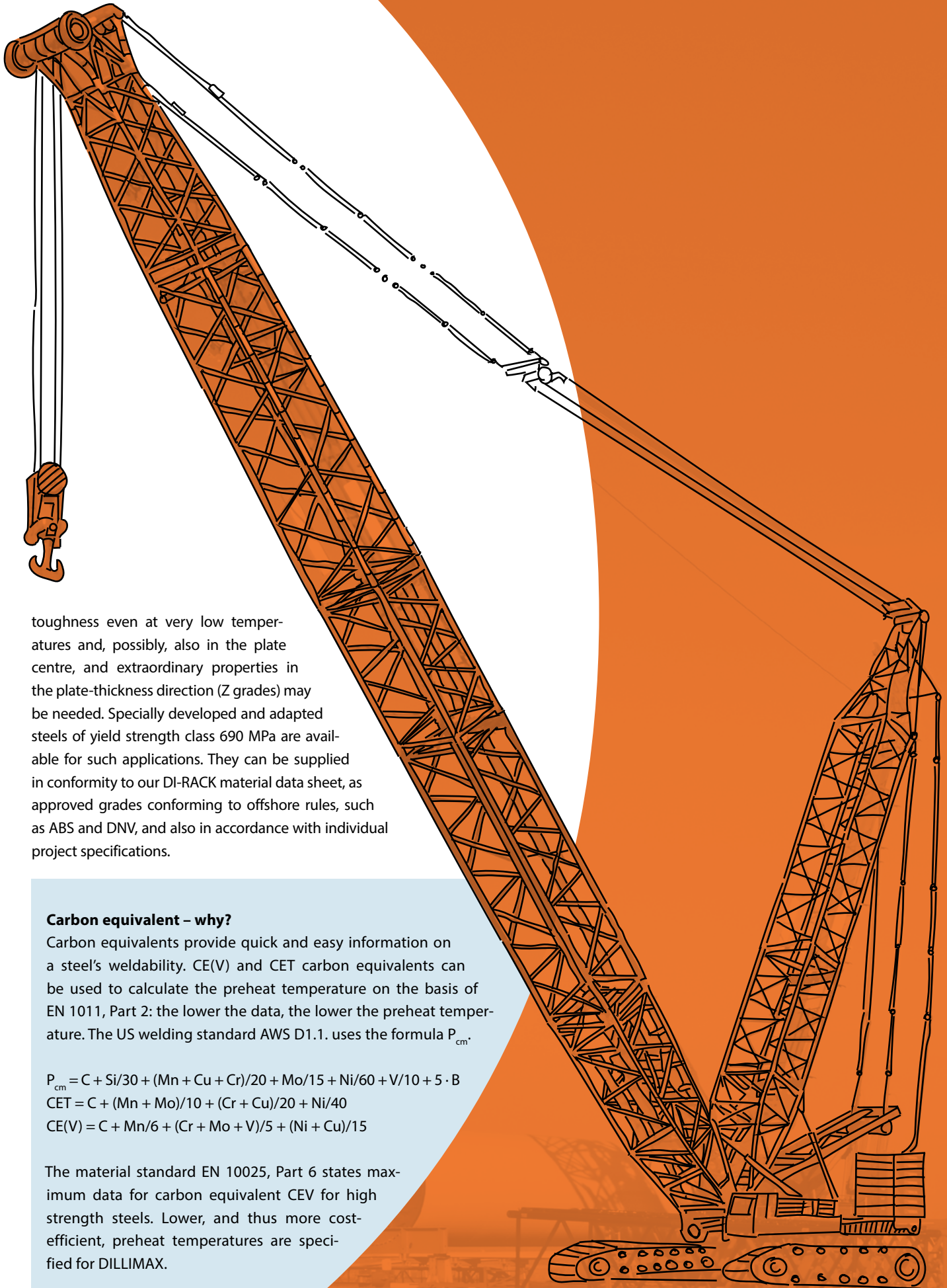
Certified quality for offshore applications

Offshore use of high strength steels necessitates an exceptionally high level of safety. Especially high strength properties, even in very thick plates, extreme Charpy V-notch

Grade	Nominal minimum yield strength [MPa] (ksi)	Charpy V-notch toughness at [°C] (°F)	Plate thickness [mm] (in.)	Designation EN 10025, Part 6
DILLIMAX 1100	1100 (160)	-40 (-40)	8 - 40 (0.3 to 1.6)	n.a.
DILLIMAX 965	960 (140)		6 - 125 (0.25 to 4.9)	S960
DILLIMAX 890	890 (130)	B/T/E		S890
DILLIMAX 690 B/T/E	690 (100)	-20/-40/-60 (-4/-40/-76)	6 - 290 ^a (0.25 to 11.4)	S690 Q/QL/QL1
DILLIMAX 550	550 (80)			S550
DILLIMAX 500	500 (72)		6 - 200 ^b (0.25 to 8)	S500

^a DILLIMAX 690 E: up to 200 mm (8 in.)

^b DILLIMAX 500 T/E and DILLIMAX 550 T/E: up to 150 mm (6 in.)



toughness even at very low temperatures and, possibly, also in the plate centre, and extraordinary properties in the plate-thickness direction (Z grades) may be needed. Specially developed and adapted steels of yield strength class 690 MPa are available for such applications. They can be supplied in conformity to our DI-RACK material data sheet, as approved grades conforming to offshore rules, such as ABS and DNV, and also in accordance with individual project specifications.

Carbon equivalent – why?

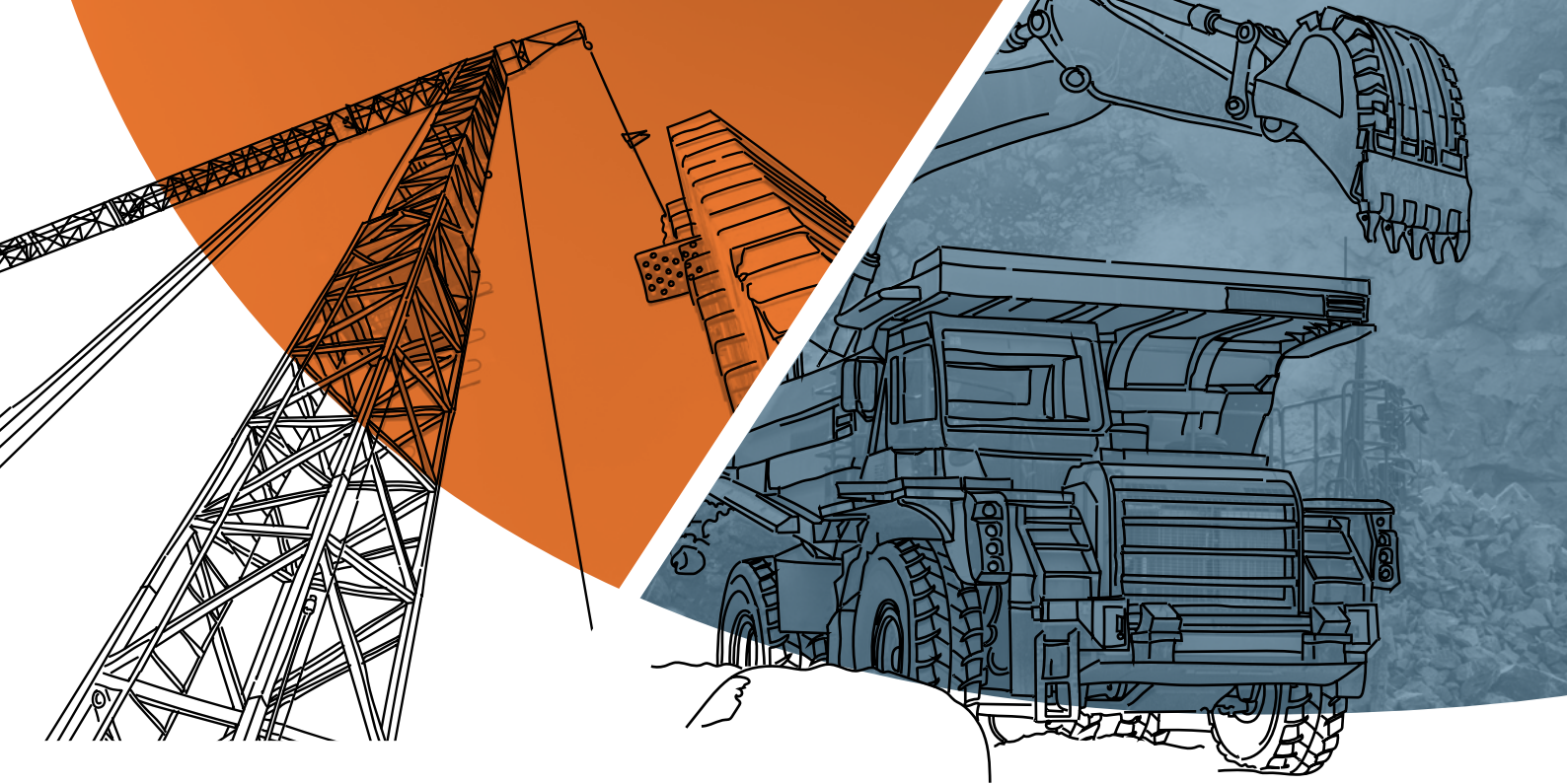
Carbon equivalents provide quick and easy information on a steel's weldability. CE(V) and CET carbon equivalents can be used to calculate the preheat temperature on the basis of EN 1011, Part 2: the lower the data, the lower the preheat temperature. The US welding standard AWS D1.1. uses the formula P_{cm}

$$P_{cm} = C + Si/30 + (Mn + Cu + Cr)/20 + Mo/15 + Ni/60 + V/10 + 5 \cdot B$$

$$CET = C + (Mn + Mo)/10 + (Cr + Cu)/20 + Ni/40$$

$$CE(V) = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15$$

The material standard EN 10025, Part 6 states maximum data for carbon equivalent CEV for high strength steels. Lower, and thus more cost-efficient, preheat temperatures are specified for DILLIMAX.



Please contact one of our partners for individual advice,
both technical or commercial.

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