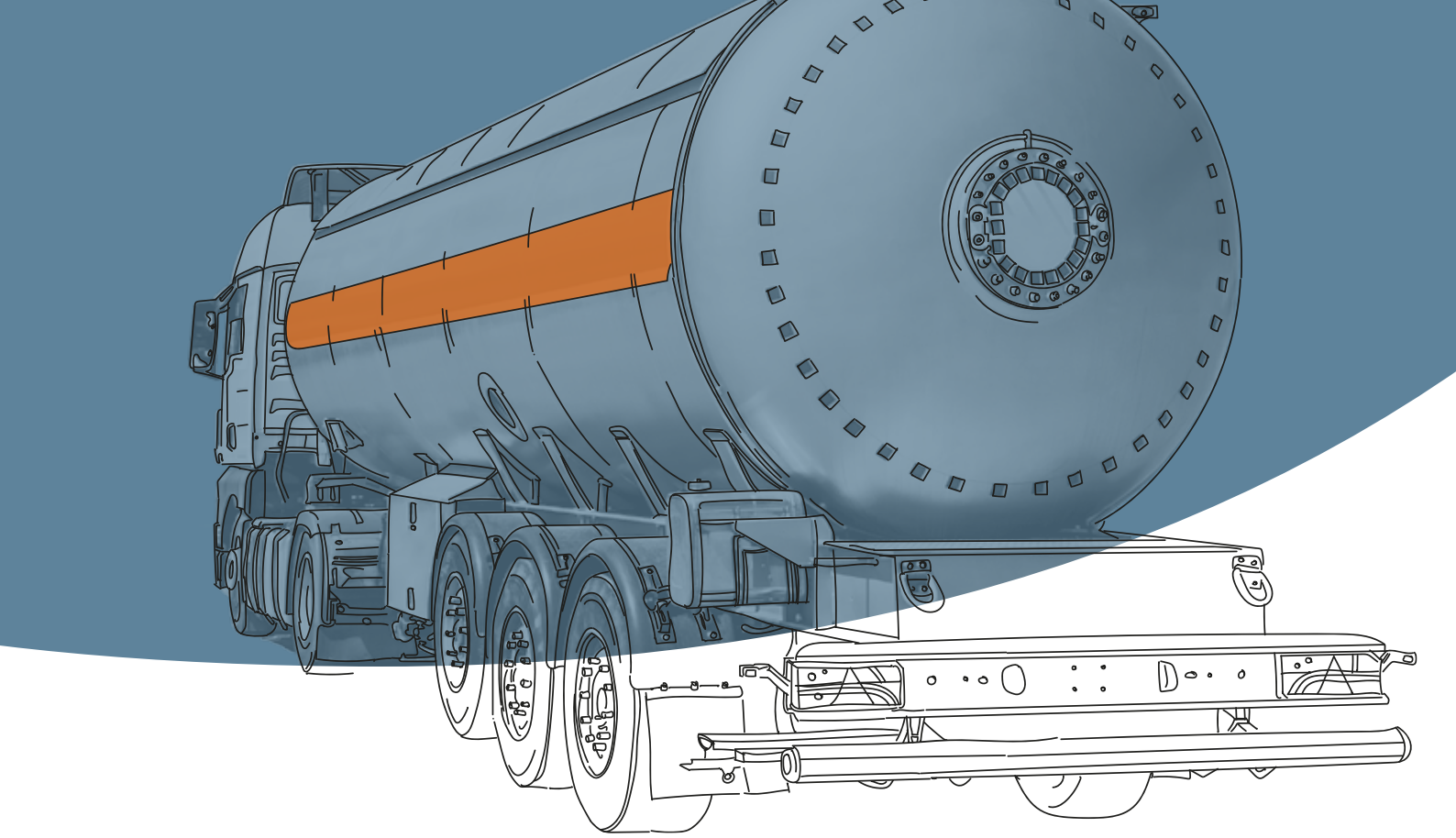


DILLINAL

The lightweight solution to boost
your haulage capacity

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 structure consists of low-CO_2 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

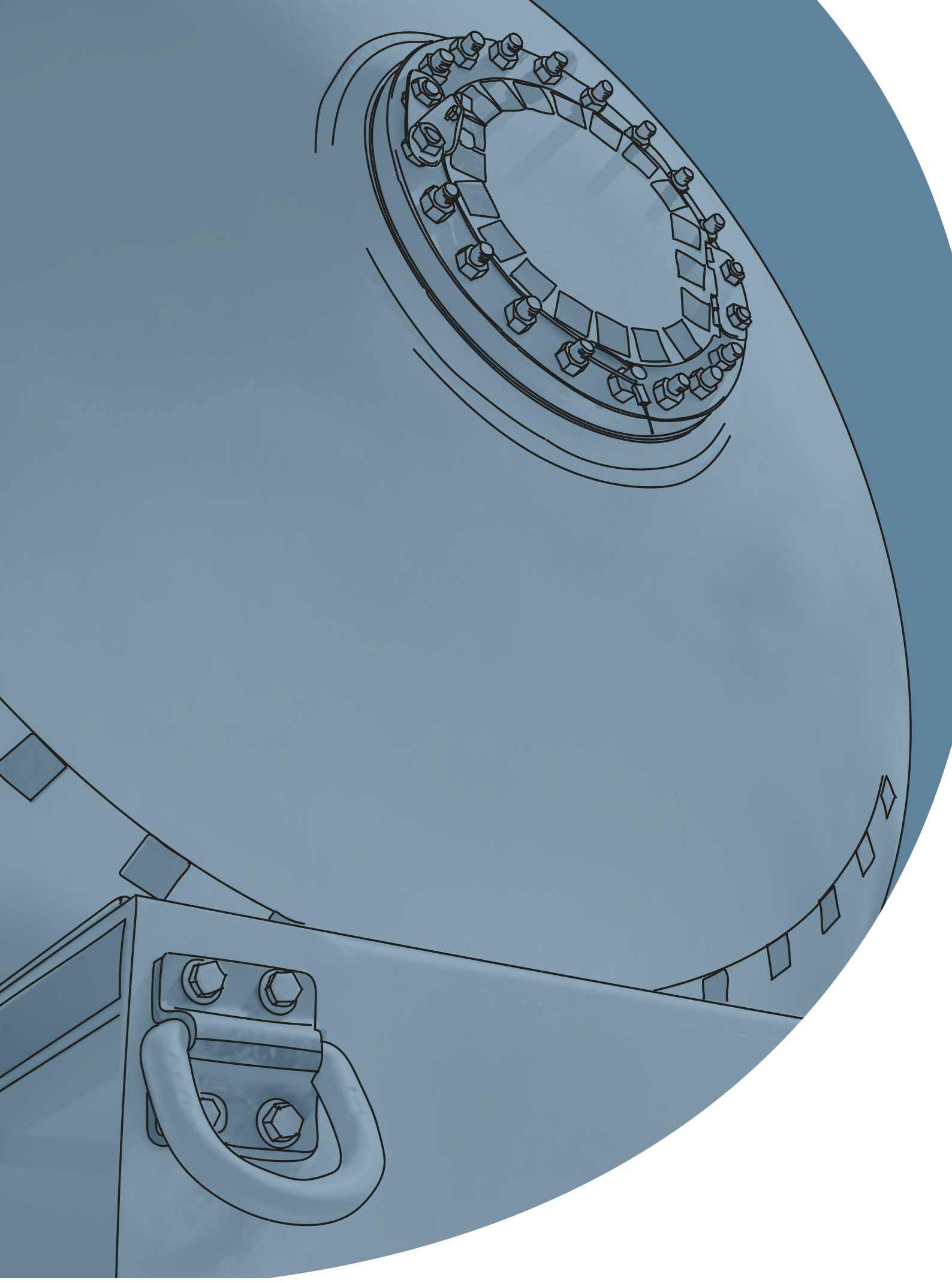
Over **2,000** different grades

Expert advice for more than **10** diverse fields of application

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

Plate weight up to **52 t**

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



DILLINAL – THE LIGHTWEIGHT SOLUTION TO BOOST HAULAGE CAPACITY

A steel that bears responsibility - and much, much more: DILLINAL was developed as a special solution for tank containers and pressure vessels. Using this weldable, fine-grained structural steel, notable for a remarkable combination of mechanical strength and toughness, we exhaustively exploit all potentials for minimising unladen weight and thus boosting transportation payloads.

The decisive factor

Anyone aiming to transport more will have to become lighter. Payload is the critical calculation factor in the haulage industry. Strict regulations apply to maximum permissible overall weight – in Germany, 90 t are permitted in rail transport, and 40 t on the country's roads.

Developed to boost your haulage capacity

A lighter gas or liquids tank allows a greater payload. Along with operational safety and reliability, minimising unladen weight is therefore one of designers' principal aims. And this is precisely where Dillinger's Research & Development work plays a critical role: we exploit all the design freedom provided by normalised steels within the scope of the applicable codes and standards. The result: DILLINAL, a high-strength normalised fine-grained structural steel with an outstanding combination of mechanical strength and toughness, available both in the basic NH grade and in the cryogenic NL grade.

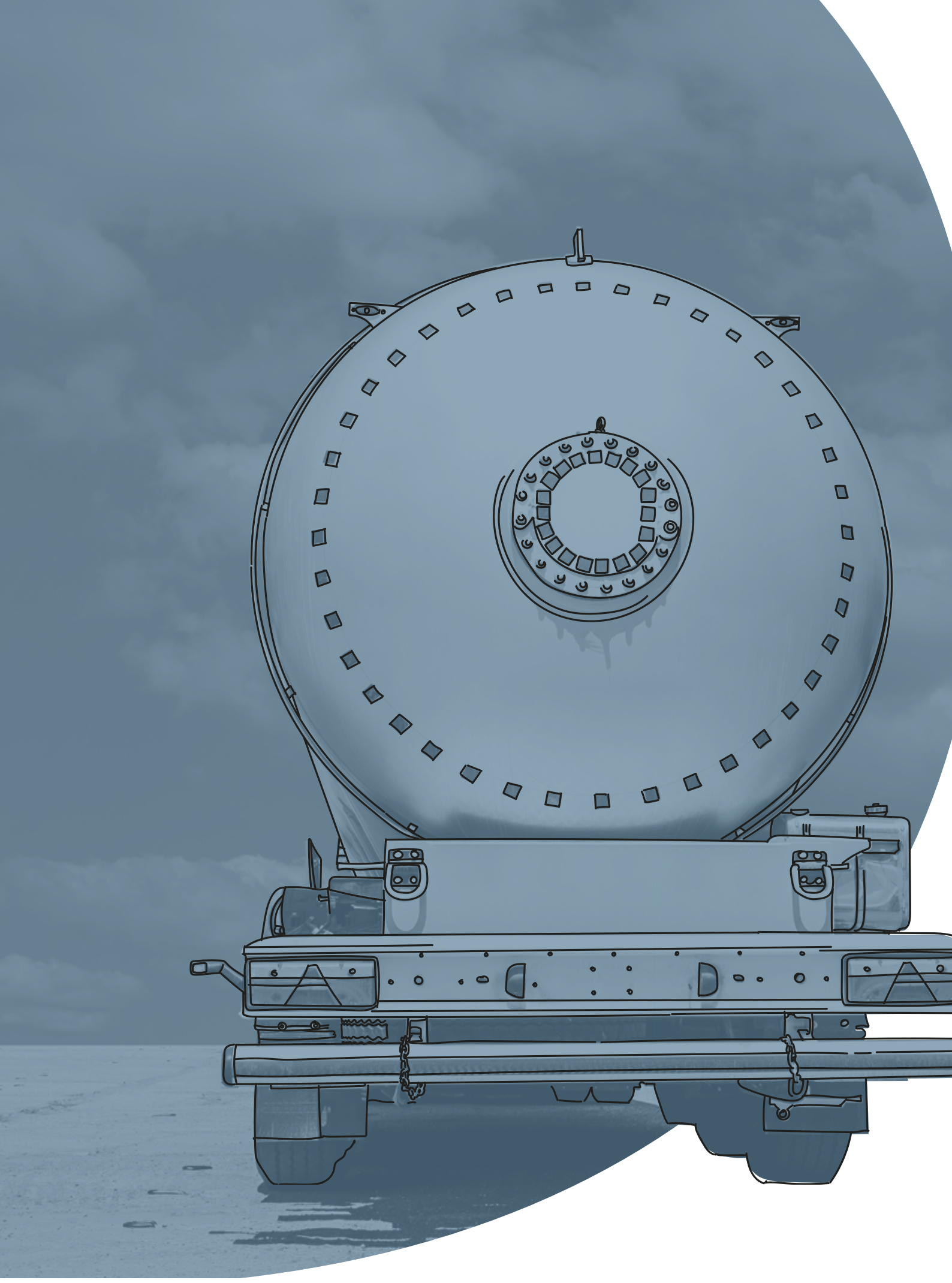
Your product benefits at a glance

- High-strength normalised fine-grained structural steel
- Maximum mechanical strength and toughness
- Available in the basic NH grade and in cryogenic NL grade
- Expanded workability for welding
- Potential for elevated HP values

Your service benefits at a glance

- Comprehensive advice provided by experts
- Preliminary fabrication of vessel shells with precision-milled weld edges on request

Discover our **E-Service**, featuring useful tools, your personal myE-Service area with all the information on your orders, and the **E-Connect** app for plate identification.



THE DIFFERENCE THAT COUNTS

Less wall thicknesses = less weight: DILLINAL delivers tangible added value. The figures speak for themselves, not only in the comparison of mechanical strength and necessary wall thickness between DILLINAL 460/630 and conventional pressure-vessel steels, but also in comparison to high-strength P460NH.

More payload on rail

A large 120 m^3 tank for a railroad wagon constructed of conventional P460NH weighs around 21.1 t. But that weight is reduced to only 19.5 t when DILLINAL 460/630 is used! Because: the required wall thickness can be reduced by up to 10%. For a total weight of 90 t, unladen weight is thus only 36.2 t, instead of 37.8 t. The tank of a rail wagon – produced using DILLINAL 460/630 – can therefore accommodate 1.6 t of extra load.

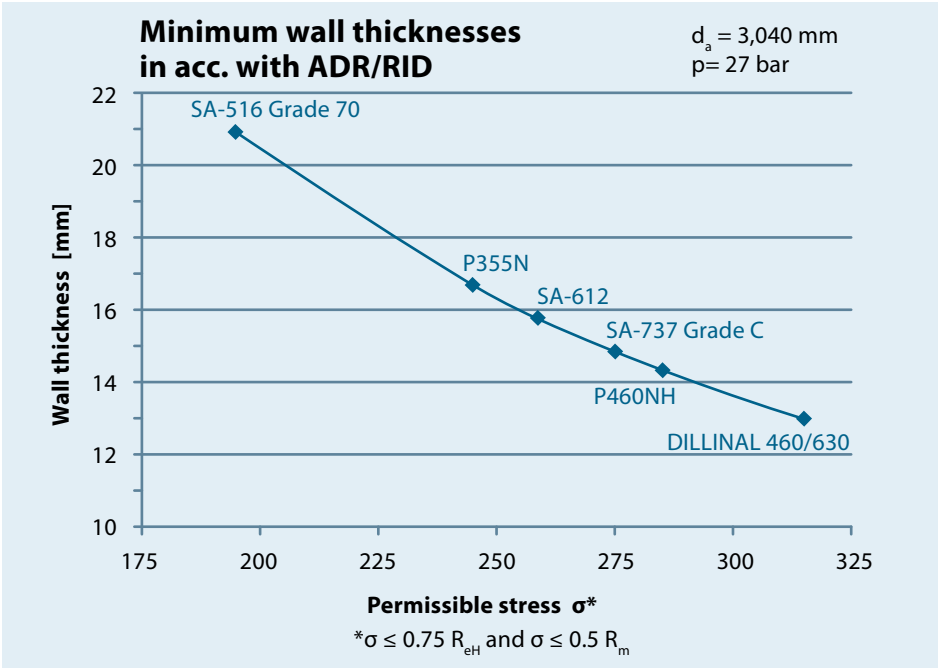
And the calculation also remains true for complete freight trains: a train consisting of thirty-two wagons carrying DILLINAL 460/630 tanks can thus haul the same amount of liquefied gas as a train of thirty-three wagons with tanks made of conventional P460NH.

Less deadweight in road transport

On an analogous comparison for road transport, the use of DILLINAL 460/630 instead of conventional P460NH results in weight savings of around 600 kg for a 50,000 litre articulated tank vehicle.

Enhanced sustainability

A higher payload capacity reduces energy consumption for haulage and thus improves the CO_2 balance for the product transported.



STANDARDISED, BUT UNCONVENTIONAL

At Dillinger, holistic capabilities in steel combine with the power of innovation. Both are vital in the development of solutions that genuinely deliver added value. To achieve the normalised fine-grained DILLINAL structural steel, the conventional P460NH described in EN 10028, Part 3, was further developed and improved.

Generating outstanding properties

DILLINAL obtains its typical properties thanks to an extremely tightly defined composition window and exact temperature control during rolling and heat treatment. The result is a high-strength normalised fine-grained structural steel with an excellent combination of mechanical strength and toughness. In both its chemical composition, mechanical characteristics and welding requirements, DILLINAL in all cases conforms to the EN 10028, Part 3 standard and thus already meets the expanded requirements stated in Option 5 (Paragraph 7.2. of EN 10028, Part 3). More detailed information on materials properties and delivery conditions can be found in DILLINGER's DILLINAL 460/630 material data sheet.

Exploit DILLINAL's extra potential

Our customers demand exceptional achievement in steel - and we aim to perform even better! This is why we deploy ultramodern processes and many years of industrial experience to set totally new standards. As in the case of DILLINAL, for example. In addition to this steel's already excellent properties, we have also incorporated improved weldability. This enables the steel user to work with higher specific heat inputs and to adjust the required toughness level in the weld with certainty.

Tensile test at room temperature on transverse specimens in acc. with EN 10002, Part 1

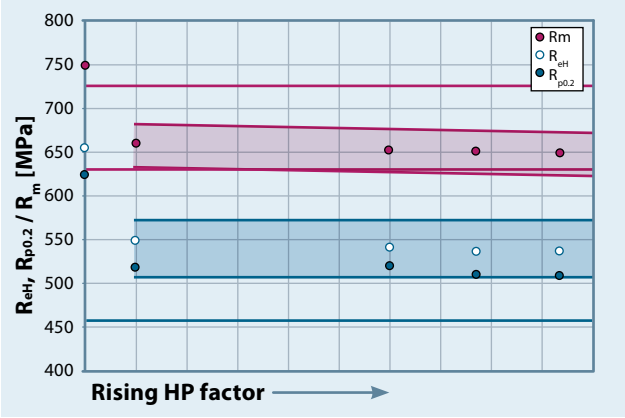
Plate thickness [mm]	Yield strength R_{eH} min. [1] [MPa]	Tensile strength R_m [MPa]	Elongation at fracture A_5 min. %
≤ 20	460	630 – 725	17

[1] In case of indefinite yield strength, $R_{p0.2}$ is to be determined in accordance with the provisions shown in EN 10028, Part 1.

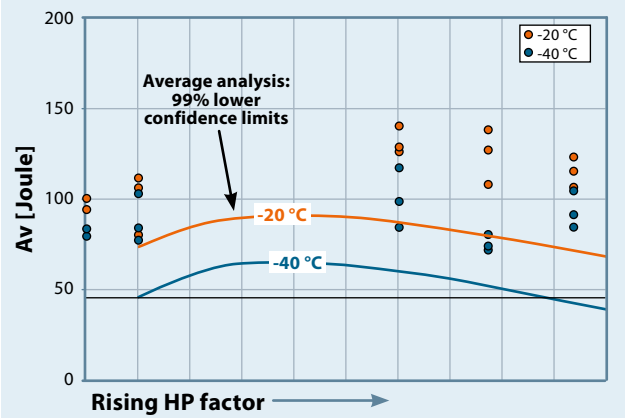
Notch toughness test on Charpy V transverse specimens in acc. with EN 10045, Part 1

	Test temperature [°C]	Charpy V-notch energy [J] min.	Charpy V-notch energy [2] [J] min.
DILLINAL 460/630 N [3]	-20	27	45
DILLINAL 460/630 NL [3]	-40	27	45

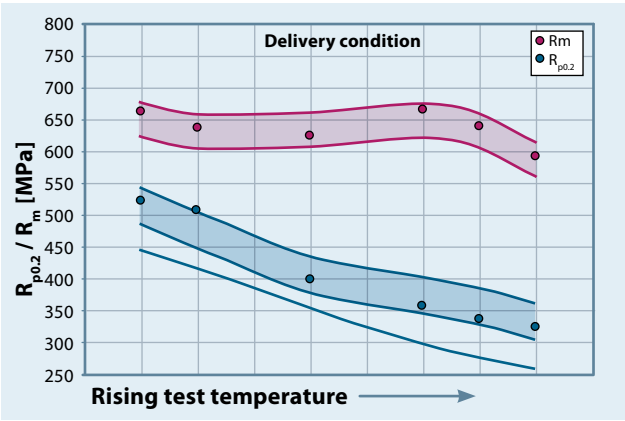
[2] At separate request
[3] Delivery condition normalised N or normalised and tempered N+T, at the producer's option



On a statistical view, 99% of all measured tensile strength data are present within the scatter band marked in red. Yield strength follows a similar pattern (blue scatter band). As the Hollomon parameters (HP) rise, the data decrease as expected, but the steel is designed such that the minima specified in the standard are never undercut.



A significant improvement in Charpy V-notch toughness has been achieved for DILLINAL. Our customers can thus use this steel at low temperatures without difficulty thanks to its enhanced reserves of toughness.



The anticipated and observed tensile and yield strength data are in all cases above the minimum levels required in EN 10028, Part 3, even at elevated temperatures.

DILLINAL exhibits virtually no loss in tensile and yield strength data in the significant material reaction to stress-relieving heat treatment. DILLINAL also excellently fulfils the standard's requirement for HP factor and actually has the potential to achieve slightly higher HP scores. Questions concerning these matters should be clarified when the enquiry is placed. Adherence to the notes concerning processing and welding is, of course, mandatory.

EFFICIENT FABRICATION - GUARANTEED

A steel on the boundary of what is technically feasible necessitates special care in processing and welding, combined with precise knowledge of materials-specific properties and potentials. Simultaneous optimisation of materials properties and workability/weldability are accompanied by enhanced reserves of safety for the customer.

Formable, weldable, and with an option for edge machining

DILLINAL 460/630 plates can be cold (room temperature) or hot (austenitisation temperature) formed for the production of components such as shell sections and vessel heads. Extremely thin plates, in particular, can cool so rapidly in the tool during hot forming that the permissible mechanical strength data are exceeded and the necessary toughness data fallen short of. Additional tempering is necessary in such cases.

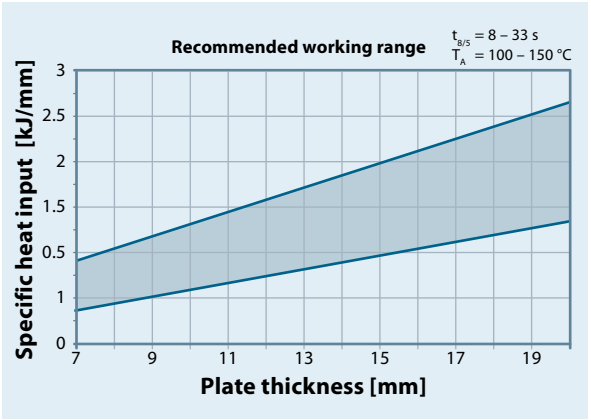
DILLINAL 460/630 can be worked and welded using shielded metal arc, gas metal arc and submerged-arc welding. The precondition for attaining high toughness in the weld is the use of basic weld filler materials.

The selection of these will also depend on the type and scope of subsequent heat treatment operations.

Heat treatment after welding is possible at temperatures < 580 °C. At reduced temperatures, DILLINAL can be heat treated using an extended holding time. The steel has the potential for HP data above the standard, this should be clarified when enquiring.

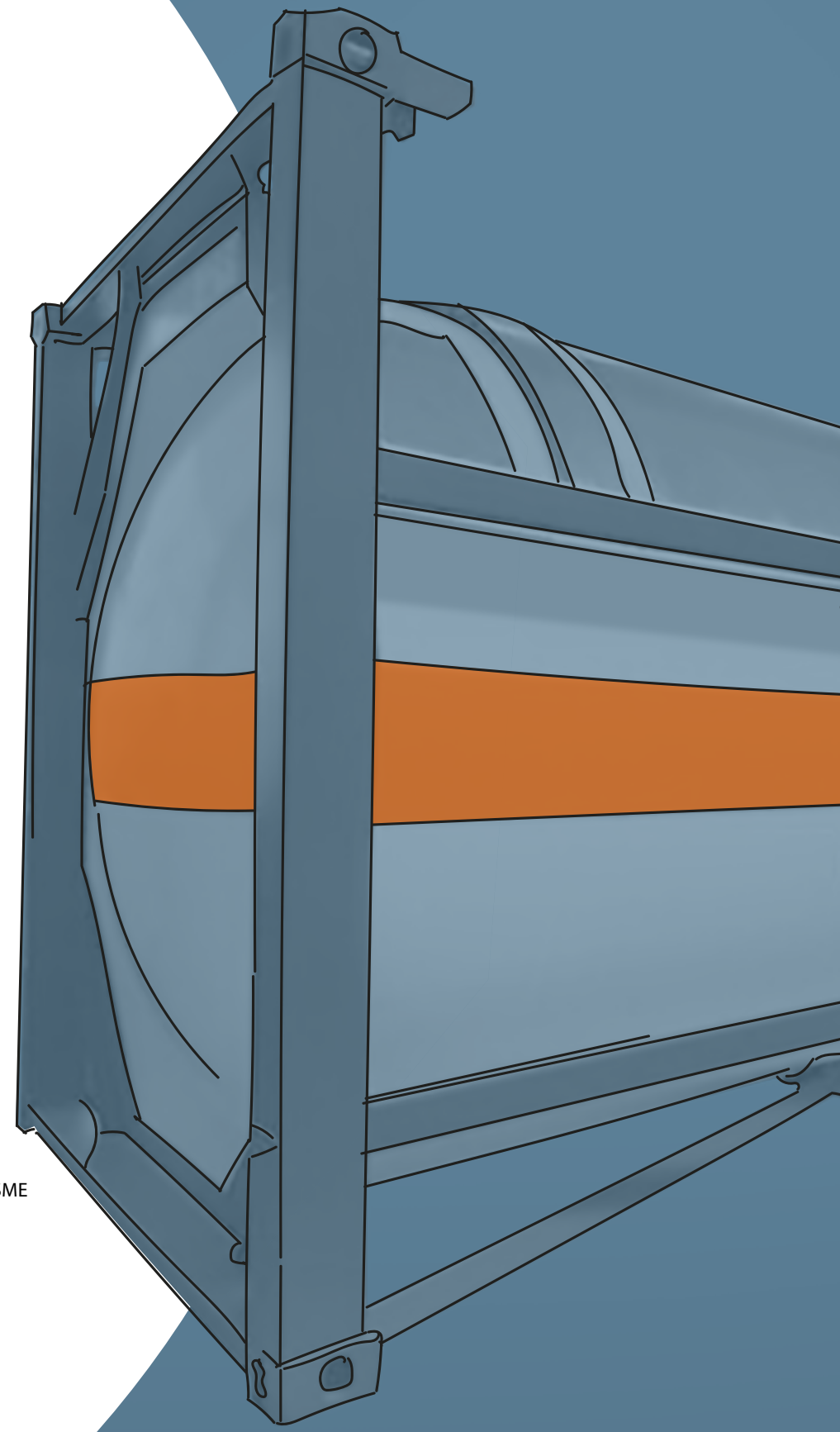
Heat and temperature control, concentrating on specific heat input, and cooling time $t_{8/5}$, are critical for the mechanical properties of the weld. The required toughness data are achieved in DILLINAL 460/630 with interpass temperatures/working temperatures of 100 to 150 °C, with cooling times $t_{8/5}$ in the 800 to 500 °C range of between 8 and 33 seconds. The greatly expanded working range in the form of possible specific heat input as a function of plate thickness is shown in the graphic below.

Detailed notes for calculation are shown in SEW 088, Supplement 2.



Weld preparation - the special service extra

If required, plates can be produced with precisely milled weld edges of various designs in accordance with the customer's specifications.



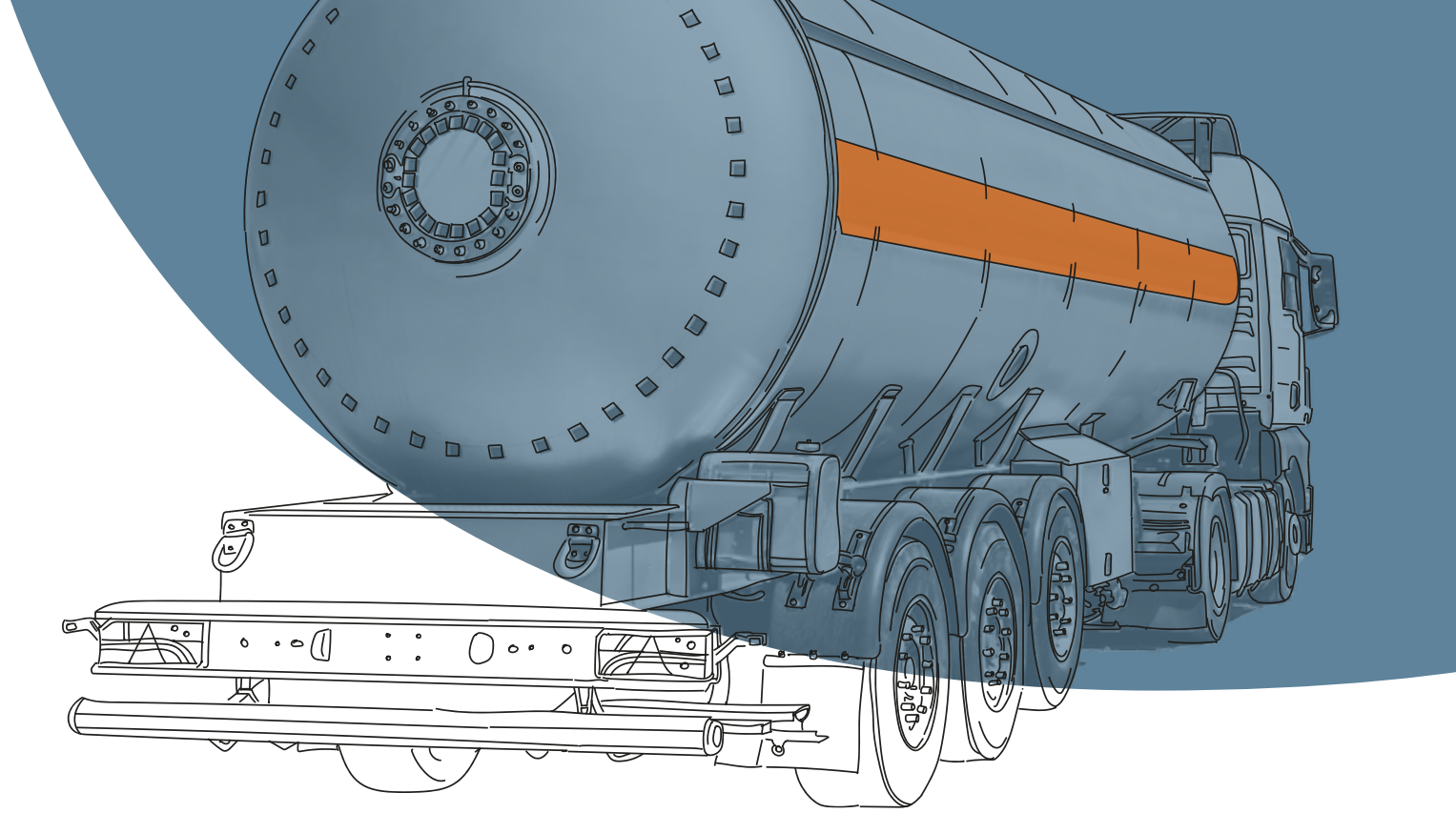
Approved for daily use
DILLINAL is under way on rail and road throughout the world: it is used here in numerous vehicles, both in fixed form and as a containerised solution for high-pressure gas tanks. Because: DILLINAL 460/630 has been assessed and is approved as a "high-strength alloyed fine-grained 460/630 structural steel for service temperatures down to -40 °C" in VdTÜV Material Data Sheet 531.

A further approval has been issued by a notified body under the Pressure Equipment Directive (PED; 2014/68/ EU) and our plates can also be used for Transportable Pressure Equipment Directive applications (TPED; 2010/35/EU). Use within the scope of the ASME VIII-2 code is possible under application of Code Case 2477. The advantages of DILLINAL 460/630 can thus also be exploited to the full in the ASME code. ASME conditions for this are as follows:

Maximum thickness:
0.79 inch (20 mm)

Maximum allowable stress Sm:
0.5 ksi (210 MPa)

Stress-relieving heat treatment:
530 – 560 °C (985 – 1,040 °F), T_{min} = 30 min.



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

Aktien-Gesellschaft der Dillinger Hüttenwerke
Werkstrasse 1 · 66763 Dillingen/Saar
Germany
Telephone +49 6831 47-0 · Telefax +49 6831 47-2212
e-mail: info@dillinger.biz · www.dillinger.de

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