

endurance<sup>®</sup>

## ENDURANCE

Cold-formed hollow sections offering superior quality and efficiency benefits







# TAILORED SOLUTIONS - INNOVATIVE AND RELIABLE

voestalpine Krems is your competent partner for innovative tubes and sections made of steel as well as complex welded assemblies. Professionalism, reliability and our global network ensure the success of our customers worldwide.

## FOCUS ON SUSTAINABILITY



At voestalpine Krems, sustainability and quality are not empty promises, but a lived reality. We are proud to contribute to creating a sustainable and quality-conscious world. Our activities in this regard were also recognized by the awarding of the gold medal by the sustainability assessment platform EcoVadis. This rating places voestalpine Krems in the top 5% in the industry - and we continue to strive for improvements.

## OUR GOAL: CO<sub>2</sub>-NEUTRALITY BY 2030

We already operate our production in Krems with 100% green electricity. Further measures to reduce energy consumption and increase environmental awareness as well as ongoing process optimization, both internally and along the entire value chain, will help to achieve our goal. We have already succeeded in reducing our footprint in terms of CO<sub>2</sub> input through processing on our premises to **14kg CO<sub>2</sub> per ton of steel**.

## UNIQUE EXPERTISE IN PROCESSING AND MATERIALS

We are one step ahead – with a wide range of services, continuous quality assurance and comprehensive development, materials and process know-how. In close coordination and collaboration with our customers, we strive to perfect all the properties of the individual components and accompany you from the drawing board to the raw materials to the ready-to-assemble product.





# AREAS OF APPLICATION

Tailored solutions for every application with technology and materials expertise:

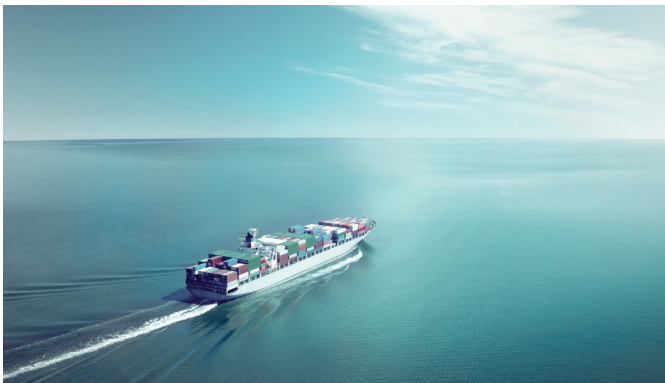
Our hollow sections in defined grades and dimensions are applied not only in demanding areas like agricultural machinery, bus and crane construction. The broad spectrum of our portfolio also includes products for the energy sector, material handling as well as construction industry, construction machinery, forklifts and system solutions for fruit growing and viticulture

## WE STAND FOR PRECISION

To make this possible whilst keeping within the tightest tolerances and being able to deliver in the agreed quality, we focus on quality assurance. Only by thinking with foresight, recognizing potential challenges at an early stage and drawing the right conclusions from them we stay one step ahead.

**Our claim is to develop precise cold-rolled tubes as well as components and welded assemblies for the automated production of our customers.**

## BEST QUALITY PACKING & TRANSPORTATION



A global network of fellow companies as well as international storage and transport agreements enable delivery with maximum time and distance savings. The ideal packaging completes the corrosion protection during storage and transport. Depending on the product and transport route, we offer the optimum type of packaging for you: Packaging precisely tailored to the process flow of our customers and the delivery conditions.

Your products are packaged using the optimum bundle sizes respectively bundle weights.





# HOLLOW SECTIONS OFFERING SUPERIOR QUALITY AND EFFICIENCY BENEFITS

Steel tubes meeting even the most demanding requirements, complying with the strictest safety requirements while guaranteeing good weldability and optimum processability – this is what voestalpine Krems stands for. We offer reliable, high-precision and safe solutions using innovative materials technologies setting new pioneering standards.

**voestalpine Krems offers three types of cold-formed hollow sections for different conditions and requirements:**

**endurance<sup>®</sup>**  
smart

Quality hollow sections for efficient processing

**endurance<sup>®</sup>**  
dynamic

Cold-rolled hollow sections for dynamic loads

**endurance<sup>®</sup>**  
extreme

High-strength hollow sections for extreme conditions





## Striking benefits

### EXCELLENT

We ensure extremely tight tolerances with regard to strip density, superior mechanical properties and chemical composition through an optimum supply of pre-materials and we guarantee consistent processing result. Even in times where steel products are in short supply.

### TAILORMADE

You can rely on our long years of comprehensive metal-forming know-how and materials expertise – together, we can find the solution that is best suited for your needs and ensures the most favorable cost-benefit ratio. We also offer intermediate dimensions, narrower tolerances as well as special steel grades and solutions. Additionally, we can assist you when it comes to customized geometries, from their development up to actual production, and thus help you save time and development expenses.

### PIONEERING

One step ahead thanks to cold forming:

- » Significantly higher surface quality
- » Approved welding performance even in the radius area
- » Improved utilization of thermomechanical fine-grained steels
- » Utilization of special steel grades (e.g. 20MnB5, 16Mo3, etc.)
- » Excellent resistance to brittle fractures thanks to high-quality steel grades
- » Smooth surfaces even when unpickled
- » Savings due to additional precoating finishing
- » No limitations when used in combination with high and maximum strength steel grades
- » Eco-friendly thanks to favorable energy footprint
- » Can be also manufactured with thicknesses of 1.5 mm

### INTERNATIONAL CERTIFICATES AND APPROVALS

- » ISO 9001
- » ISO 14001 / ISO 45001
- » ISO 50001
- » IATF 16949
- » EN 1090-1
- » EN 10025-1
- » EN 10219-1
- » EN 1317-5 + A2/AC
- » EN ISO 3834-2

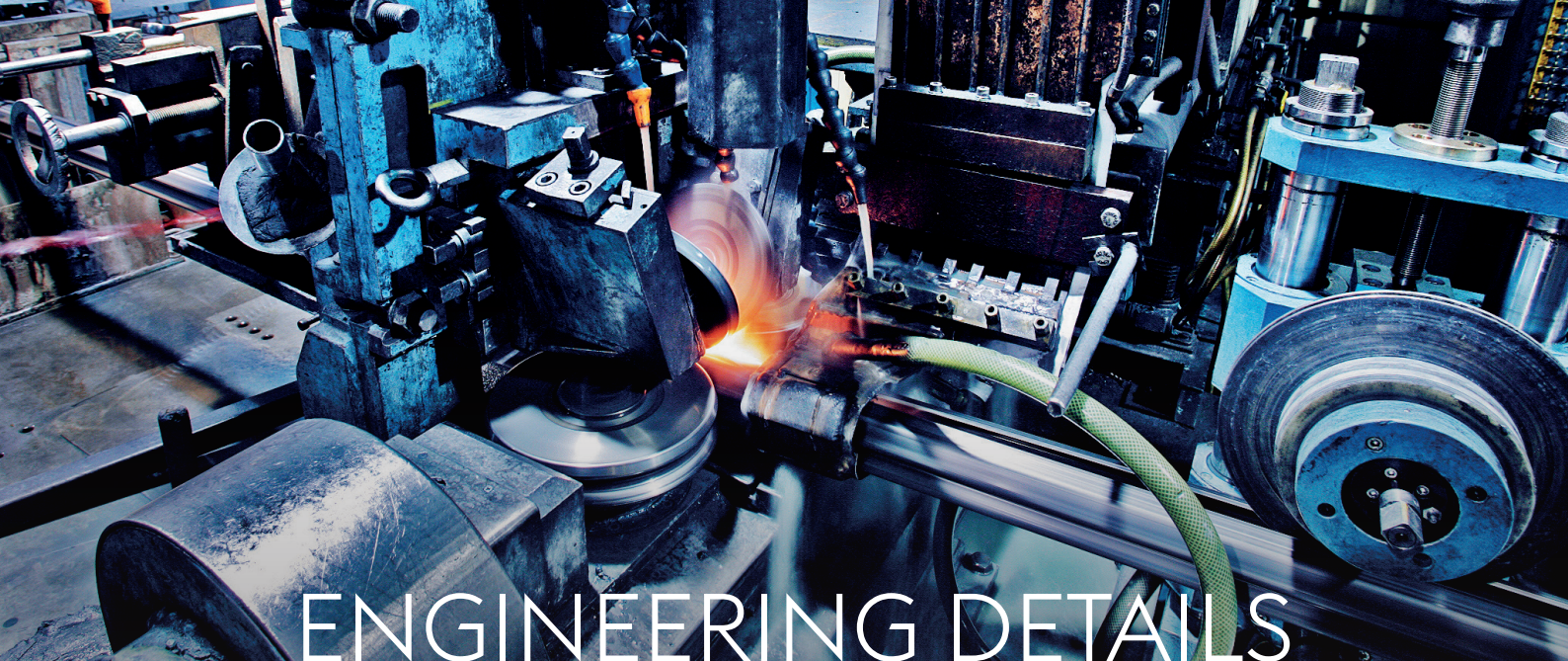
### EFFICIENT

Production at room temperature allows both compliance with the tightest possible cross-sectional and straightness tolerances as well as even, smooth surfaces. Due to the extremely homogenous surface structure no expensive pre-painting finishing processes such as sand-blasting are required.

### SUITABLE FOR HOT-DIP GALVANIZING

All endurance hollow sections are galvanizable according to the ISO 1461 application standard: specifications and test methods. This applies to higher strength, microalloyed steel grades up to a grade of S550M. It has to be stated that materials above S500M require a separate procedure test for hot-dip galvanizing (see DaSt Guideline 022 - "Hot-dip galvanizing of load-bearing steel components").





# ENGINEERING DETAILS

## Manufacturing process

At voestalpine Krems, tubes and hollow sections are manufactured continuously from steel strips using state-of-the-art forming technologies.

Strips are shaped either directly or by means of a round-tube forming process to achieve the required cross-section.

The tubes are then high-frequency welded and their exterior weld burrs are removed.

Having passed through a cooling line, they are rolled in sizing stands until they reach their finished dimensions.

### endurance smart

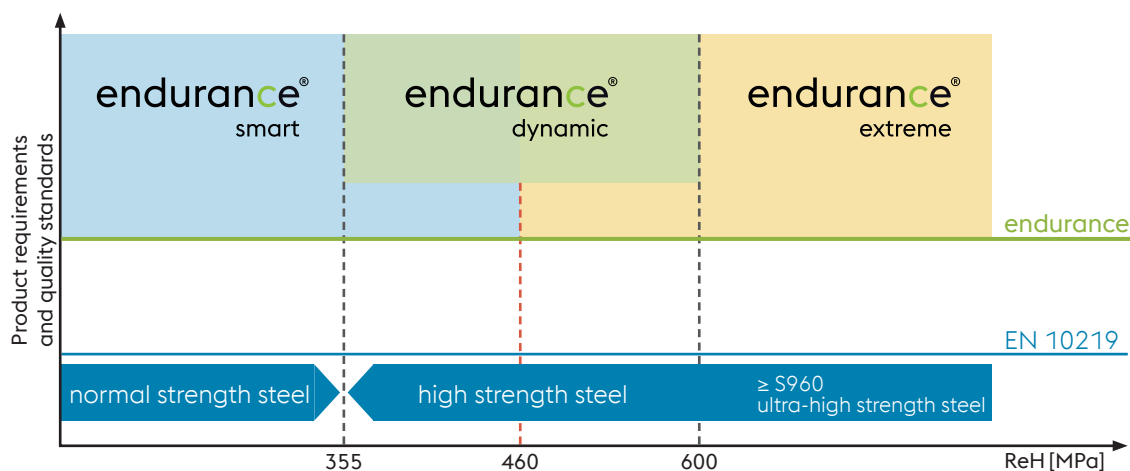
- » Steel grades acc. to EN 10305-5, EN 10219-1, 3 and EN 10149 with yield strength up to 460 MPa

### endurance extreme

- » Fine-grained structural steels according to EN 10149 or EN 10219-3 from S500MH up to S960MH

### endurance dynamic

- » voestalpine special steel grade
- » Micro-alloyed and thermomechanically rolled high-purity steel
- » Yield strength  $ReH$  [MPa] 355 – 600





## Technical delivery conditions and standards

The manufacturing tolerances of our tubes and hollow sections are in conformity with EN 10305-5 or EN 10219-2. Technical delivery

conditions such as surface finish, tests, quantity tolerances, handling of complaints, etc. comply with EN 10305-5 or EN 10219-1, 3.

	EN 10219 Part 1, 2 und 3	EN 10305-5
<b>Title</b>	Cold-formed welded structural hollow sections of non-alloy and fine grain steels	Steel tubes for precision applications
<b>Radii/edges</b>	Edge or radii T ≤ 6 mm: 1,6 T to 2,4 T 6 < T ≤ 10 mm: 2,0 T to 3,0 T T > 10 mm: 2,4 T to 3,6 T	Edge area T ≤ 2,5 mm: C max. 1,5 x T 2,5 < T ≤ 4 mm: C max. 2,2 x T
<b>Straightness</b>	0,15 % of overall length in terms of 1 m: max. 3 mm	Shorter side ≤ 30 mm: 0,0025 x length shorter side > 30 mm: 0,0015 x length in terms of 1 m: max. 3 mm
<b>Squareness</b>	± 1°	± 1°
<b>Curvature of lateral surface</b>	max. 0,8 %, min. 0,5 mm	Curvature within dimensional tolerance
<b>Wall thickness tolerance</b>	T ≤ 5 mm: ± 10 % T > 5 mm: ± 0,5 mm not applicable in edge and weld seam areas	T ≤ 1,5 mm ± 0,15 mm T > 1,5 mm ± 10 % or max. ± 0,35 mm (smaller value applicable) upper limits not applicable in edge and weld seam areas
<b>Dimensional tolerances</b>	H, B < 100 mm: ± 1 % (min. 0,5 mm) 100 ≤ H, B ≤ 200: ± 0,8 % H, B > 200: ± 0,6 %	see Table of Standards
<b>Torsion</b>	v ≤ 2 mm + 0,5 mm/m	B, H ≤ 30 mm: v ≤ 3 mm B, H > 30 mm: v ≤ B, H / 10





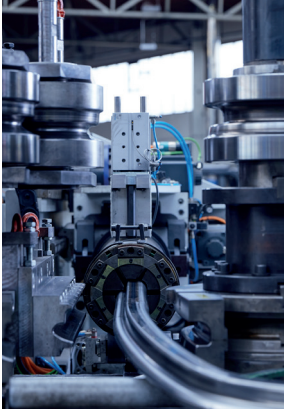
## MORE THAN JUST TUBES - FROM READY-TO-INSTALL COMPONENTS TO WELDED ASSEMBLIES

voestalpine Krems offers you state-of-the-art processing and machining technologies that help you reduce your costs, ranging from bending, laser cutting, drilling, welding, pressing and shaping to post-processing and finishing (single-piece galvanizing, phosphating, EDP coating as well as other coating processes). We are your experienced partner in producing ready-to-install components and welded assemblies.

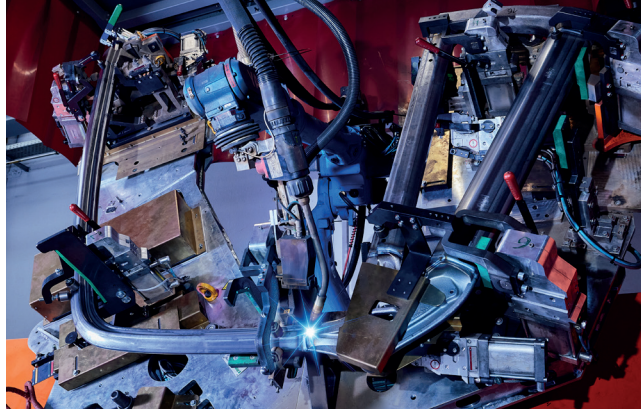
We integrate these processes into our production lines and ensure economical solutions. At your request, we can provide you with tailor-made, ready-to-install components to optimize your manufacturing processes and costs even further.

**You can count on our comprehensive processing, finishing and problem-solving expertise!**

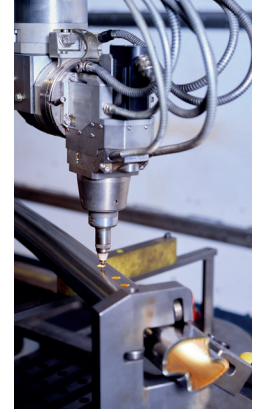




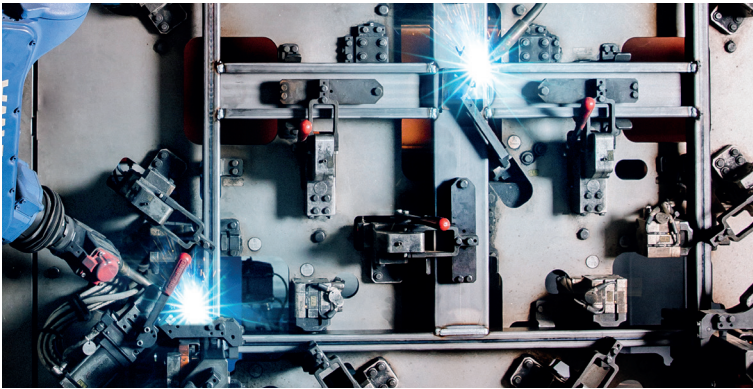
» Roll and mandrel bending



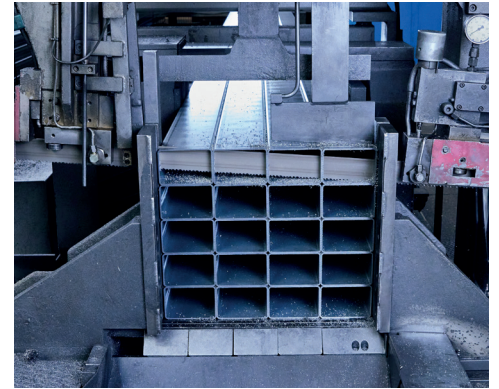
» Robotic welding cells



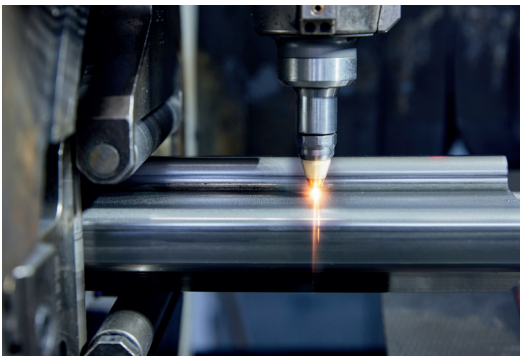
» 5-axis laser



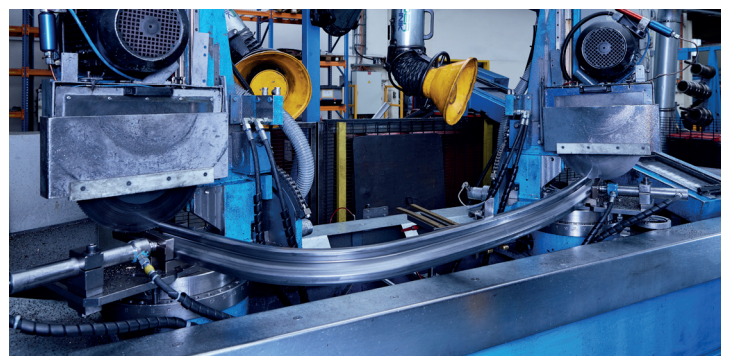
» Robotic welding cells for complex welded assemblies



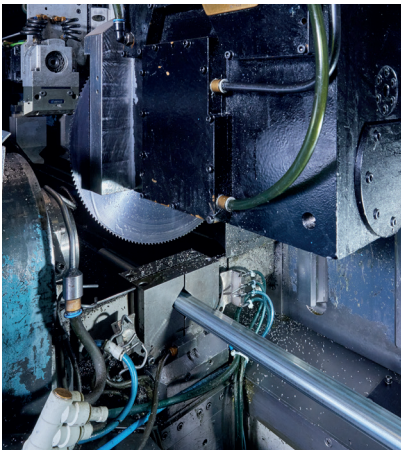
» Batch saw



» Tube laser



» 3D-miter saw



» CNC-miter saw



» Automated sorting and bundling





## DEVELOPMENT SUPPORT

# BENEFIT FROM OUR COMPREHENSIVE KNOW-HOW

We are a well-established manufacturer and supplier of roll-formed, longitudinally welded rectangular and square tubes as well as special tubes, profiles and further processed products with a focus on quality and service.

**With our comprehensive materials expertise and broad experience, we aim to support our customers right from the product development phase.**

## EARLY COLLABORATION OFFERS GREAT ADVANTAGES::

- » Optimization of the product design for a more cost-effective and stable manufacturing
- » Minimization of processing risks by taking downstream processes into account
- » Improved tolerance design through a holistic understanding of the product
- » Smooth production start-up
- » Cost reduction in terms of total cost of ownership (TCO)



# APPLICATION CONSULTING TOGETHER WE PERFECT YOUR ASSEMBLIES

As experts in our products and manufacturing processes, we offer application consulting to our customers.

**We advise on the application and further processing of our products in order to increase the durability and quality of the end product or to reduce work steps and thus save costs.**

## SUPPORT FROM OUR EXPERTS

Together we develop customized solutions for your requirements.

- » From welding operations to complex welded assemblies
- » Trimming operations such as laser cutting, sawing or punching
- » Bending operations on tubes, special tubes or profiles
- » Application and use of corrosion protection measures



endurance<sup>®</sup>  
smart



# COUNT ON A COMPREHENSIVELY TRIED AND-TESTED SOLUTION

**endurance smart** stands out due to its easy processability and wide range of application. These high-precision hollow sections are made from the best materials available and excel thanks to corrosion resistance and superior efficiency.

## SMART AND SOPHISTICATED ADVANTAGES

### Excellent processing and machining characteristics

Easy to cut, weld, finish and join, its high-quality prematerial ensures trouble-free and cost-efficient processing and machining.

### Wide range of dimensions

endurance smart covers all common square and rectangular dimensions in the tensile strength range up to 460MPa. The subsequent page lists all technically possible square tubes in unpickled, pickled and galvanized surface finishes.

### Forming technology

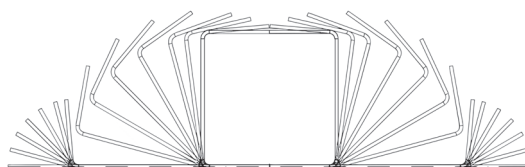
In addition to conventional round tube forming, we also offer direct forming technology for parts of our tube range.

#### The advantages are convincing:

- » Uniform radii and low C/T ratio
- » Reduced residual stresses
- » Tight tolerances for weld seam centricity

Compared to standard round tube forming, the finished tube has **3 to 10%** higher yield values.

Maximum range of dimensions:



Height x width [mm]	wall thickness [mm]	endurance dynamic
120 x 120	8	up to S600M

## FACTORY STANDARD ENDURANCE SMART

The standards EN10305-5 and EN10219 parts 1, 2 and 3 are used as the basis for the production of our square and rectangular tubes. In addition to the standard, our own factory standard endurance smart applies to tubes produced by voestalpine Krems GmbH.

We further restrict surface requirements, limit dimensions and many other parameters compared to the normative specifications. Ask your sales contact - we will be happy to advise you.



# SQUARE TUBES RANGE

In the table below you can find all technically producible square tubes up to a yield strength of 460MPa according to the endurance smart factory standard. The difference in color indicates the surface finish.

The symbols indicate the possible forming technologies.

For special dimensions, please contact your contact person in our sales team.

## endurance smart in the yield strength range 235-460MPa

Dimension [mm]		Wall thickness [mm]												
Height	Width	1,2	1,5	2,0	2,5	3,0	3,5	4,0	5,0	6,0	6,3	7,0	8,0	10,0
20	20	○	○	○										
25	25	○	○	○	○	○								
30	30	○	○/□	○/□	○/□	○/□	○	○						
35	35		○/□	○/□	○/□	○/□	○	○	○					
40	40		○/□	○/□	○/□	○/□	○	○	○					
45	45		□	○/□	○/□	○/□	○	○	○					
50	50		□	○/□	○/□	○/□	○/□	○/□	○/□	○	○			
55	55		□	○/□	○/□	○/□	○/□	○/□	○/□	○	○			
60	60		□	○/□	○/□	○/□	○/□	○/□	○/□	○/□	○			
65	65			○/□	○/□	○/□	○/□	○/□	○/□	○/□	○/□	○		
70	70			○/□	○/□	○/□	○/□	○/□	○/□	○/□	○/□	○/□	□	
75	75			○/□	○/□	○/□	○/□	○/□	○/□	○/□	○/□	□	□	
80	80			○/□	○/□	○/□	○/□	○/□	○/□	○/□	○/□	□	□	
85	85				□	□	□	□	□	□	□	□	□	
90	90				□	□	□	□	□	□	□	□	□	
95	95				□	□	□	□	□	□	□	□	□	
100	100				□	○/□	○/□	○/□	○/□	○/□	○/□	○/□	○/□	○
105	105					○/□	○/□	○/□	○/□	○/□	○/□	○/□	○/□	○
110	110					○/□	○/□	○/□	○/□	○/□	○/□	○/□	○/□	○
115	115					○/□	○/□	○/□	○/□	○/□	○/□	○/□	○/□	○
120	120					○/□	○/□	○/□	○/□	○/□	○/□	○/□	○/□	○
125	125					○	○	○	○	○	○	○	○	○
130	130					○	○	○	○	○	○	○	○	○
135	135							○	○	○	○	○	○	○
140	140							○	○	○	○	○	○	○
145	145							○	○	○	○	○	○	○
150	150							○	○	○	○	○	○	○
155	155							○	○	○	○	○	○	○
160	160							○	○	○	○	○	○	○
165	165							○	○	○	○	○	○	○
170	170							○	○	○	○	○	○	○
175	175							○	○	○	○	○	○	○
180	180							○	○	○	○	○	○	○
185	185							○	○	○	○	○	○	○
190	190							○	○	○	○	○	○	○
195	195							○	○	○	○	○	○	○
200	200							○	○	○	○	○	○	○
205	205								○	○	○	○	○	○
210	210								○	○	○	○	○	○
215	215								○	○	○	○	○	○
220	220									○	○	○	○	○

Surface finishes pickled, galvanized	Surface finishes unpickled	Forming Technologies ○ Round tube forming   □ Direct forming   ○/□ Both available
---	-------------------------------	--

# RECTANGULAR TUBES RANGE

In the table below you can find all technically producible rectangular tubes up to a yield strength of 460MPa according to the endurance smart factory standard. The difference in color indicates the surface finish.

The symbols indicate the possible forming technologies.

For special dimensions, please contact your contact person in our sales team.

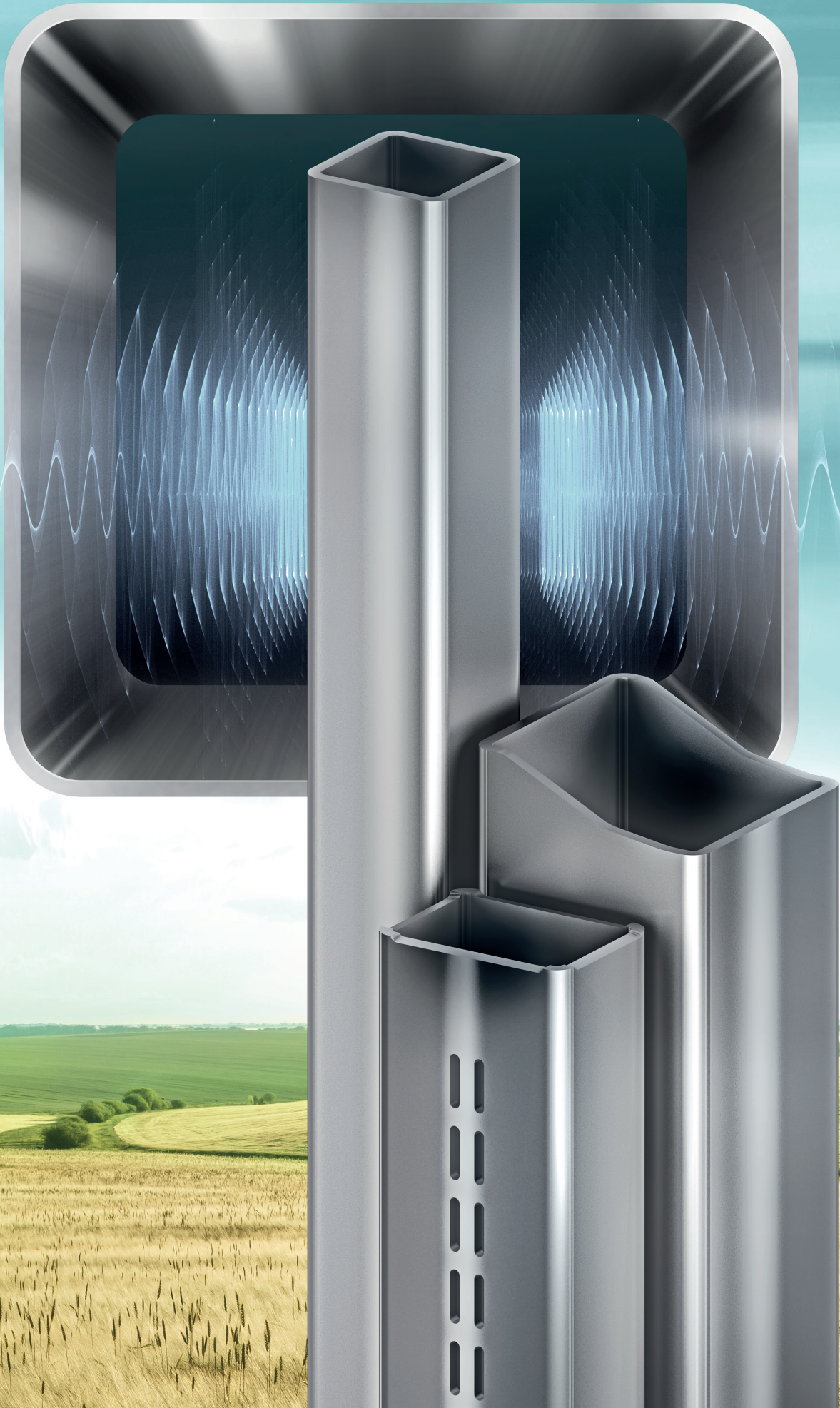
## endurance smart in the yield strength range 235-460MPa

Dimension [mm]		Wall thickness [mm]												
Height	Width	1,2	1,5	2,0	2,5	3,0	3,5	4,0	5,0	6,0	6,3	7,0	8,0	10,0
20	15	○	○	○										
30	10	○	○	○										
30	20	○	○	○	○	○								
40	20	○	○	○	○	○								
40	30		○/□	○/□	○/□	○/□	○	○						
50	20		○	○	○	○								
50	30		○/□	○/□	○/□	○/□	○	○	○					
50	40		□	○/□	○/□	○/□	○	○	○					
60	30		□	○/□	○/□	○/□	○	○	○					
60	40		□	○/□	○/□	○/□	○/□	○/□	○/□	○	○			
70	40		□	○/□	○/□	○/□	○/□	○/□	○/□	○/□	○	○		
80	40		□	○/□	○/□	○/□	○/□	○/□	○/□	○/□	○	○		
80	50			○/□	○/□	○/□	○/□	○/□	○/□	○/□	○/□	○/□		
80	60			○/□	○/□	○/□	○/□	○/□	○/□	○/□	○/□	○/□		
90	50			○/□	○/□	○/□	○/□	○/□	○/□	○/□	○/□	○/□	□	
100	50			□	○/□	○/□	○/□	○/□	○/□	○/□	○/□	○/□		
100	60				○/□	○/□	○/□	○/□	○/□	○/□	○/□	○/□		
100	80				□	□	□	□	□	□	□	□	□	□
110	60					□	□	□	□	□	□	□	□	□
120	60					□	□	□	□	□	□	□	□	□
120	80					○/□	○/□	○/□	○/□	○/□	○/□	○/□	○/□	○
140	70					○/□	○/□	○/□	○/□	○/□	○/□	○/□	○	○
140	80					○/□	○/□	○/□	○/□	○/□	○/□	○/□	○/□	○
150	50					□	□	□	□	□	□			
150	75					○/□	○/□	○/□	○/□	○/□	○/□	○/□	○/□	○
150	100					○/□	○/□	○/□	○/□	○	○	○	○	○
160	80					○	○	○	○	○	○	○	○	○
160	90					○	○	○	○	○	○	○	○	○
180	100							○	○	○	○	○	○	○
200	100							○	○	○	○	○	○	○
200	120							○	○	○	○	○	○	○
200	150							○	○	○	○	○	○	○
220	120							○	○	○	○	○	○	○
250	150							○	○	○	○	○	○	○
260	140							○	○	○	○	○	○	○
260	180									○	○	○	○	○

Surface finishes pickled, galvanized	Surface finishes unpickled	Forming Technologies ○ Round tube forming   □ Direct forming   ○/□ Both available
---	-------------------------------	--



endurance<sup>®</sup>  
dynamic



# COUNT ON A DYNAMIC SOLUTION FOR DYNAMIC LOADS

## RANGE OF DIMENSIONS AND TOLERANCES

### GEOMETRIC PROPERTIES AND PROCESSABILITY

Benchmarking of standards on the example of a hollow section 120/120x8

	<b>EN 10219:2019</b> Cold formed welded steel structural hollow sections from unalloyed structural steel and fine-grained structural steel		<b>EN 10210:2019</b> Hot-finished steel structural hollow sections from unalloyed structural steel and fine-grained structural steel		<b>endurance<sup>®</sup> dynamic</b>	
Outer radii R	2,0 to 3,0 T	16 - 24	3T max. per rounding	max. 24	-	-
Edges C1, C2	2,0 to 3,0 T	16 - 24	3T max. per rounding	max. 24	<b>nom. 1,5 x T</b>	<b>max. 12</b>
Straightness deviation	0,15% over total length; max. 3mm/m		0,2% over total length; 3mm/m		<b>0,15% over total length</b>	
Twisting deviation	2mm + 0,5 mm /m		2mm + 0,5 mm /m		<b>0,8°/m</b>	
Squareness	± 1°	89 - 91	± 1°	89 - 91	± 1°	<b>89 - 91</b>
Camber concave/convex of the sides	max. 0,8%; but at least 0,5 mm		1%		<b>Camber within the dimension tolerance</b>	
Wall thickness tolerance	T>5mm: ± 0,5mm	7,5 - 8,5	-10%	min. 7,2*	± 0,5 mm	<b>7,5 - 8,5</b>
Wall thickness to-tolerance in the weld seam area	Wall thickness in the weld seam area not restricted (area 4xT)		Wall thickness in the weld seam area not restricted (area 4xT)		≥ 85% of the base material thickness	<b>≥6,8</b>
Dimension tolerance height	100 ≤ H ≤ 200: ± 0,8%	119,04 - 120,96	± 1%, but at least ± 0,5 mm	118,8 - 121,2	± 0,5 mm	<b>119,5 - 120,5</b>
Dimension tolerance width	100 ≤ H ≤ 200: ± 0,8%	119,04 - 120,96	± 1%, but at least ± 0,5 mm	118,8 - 121,2	± 0,5 mm	<b>119,5 - 120,5</b>
Weld seam centricity	no restriction		no restriction		±15% of the side length	<b>102 - 138</b>

\* The upper limiting dimension is given by the limiting deviation of the mass.

Excellent fatigue strength of endurance dynamic hollow sections due to narrowest chamfer dimensions  $\leq 1,5xT$ . Restricted tolerances compared to the hollow section standard EN 10219 enable repeatable automated processability.



# SQUARE TUBES RANGE

In the table below you can find all technically producible rectangular tubes up to a yield strength of 460MPa according to the endurance smart factory standard. The difference in color indicates the surface finish.

The symbols indicate the possible forming technologies.

**For special dimensions, please contact your contact person in our sales team.**

endurance dynamic  
square tubes S355M - S600M

Dimensions [mm]		Wall thickness [mm]																
Height	Width	3,0	3,5	4,0	4,5	5,0	5,5	6,0	6,3	6,5	7,0	7,1	7,5	8,0	8,5	9,0	9,5*	10,0*
30	30	O/□	○	○														
35	35	O/□	○	○														
40	40	O/□	○	○	○	○												
45	45	O/□	○	○	○	○												
50	50	□	□	□	□	□	○*	○**	○**									
55	55	□	□	□	□	□	○*	○**	○**									
60	60	□	□	□	□	□	□*	□*	□*									
65	65	□	□	□	□	□	□*	□*	□*									
70	70	□	□	□	□	□	□	□	□	□	□	□						
75	75	□	□	□	□	□	□	□	□	□	□	□	□	□				
80	80	□	□	□	□	□	□	□	□	□	□	□	□	□	□			
85	85	□	□	□	□	□	□	□	□	□	□	□	□	□	□			
90	90	□	□	□	□	□	□	□	□	□	□	□	□	□	□			
95	95	□	□	□	□	□	□	□	□	□	□	□	□	□	□			
100	100	□	□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	○	○	○	○
105	105	□	□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	○	○	○	○
110	110	□	□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	○	○	○	○
115	115	□	□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	○	○	○	○
120	120	□	□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	○	○	○	○
127	127	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
130	130	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
135	135			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
140	140			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
145	145			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
150	150			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
155	155			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
160	160			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
170	170			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
180	180			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
190	190			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
200	200			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
210	210					○	○	○	○	○	○	○	○	○	○	○	○	○
220	220									○	○	○	○	○	○	○	○	○

Surface unpickled	upon request	Forming Technologies <input type="radio"/> Round tube forming <input type="checkbox"/> Direct forming <input type="checkbox"/> Both available
-------------------	--------------	--

\* For steel grades up to S550M

\*\* For steel grades up to S500M

# RECTANGULAR TUBES RANGE

In the table below you can find all technically producible rectangular tubes up to a yield strength of 460MPa according to the endurance smart factory standard. The difference in color indicates the surface finish.

The symbols indicate the possible forming technologies.

**For special dimensions, please contact your contact person in our sales team.**

## endurance dynamic rectangular tubes S355M - S600M

Dimensions [mm]		Wall thickness [mm]																
Höhe	Breite	3,0	3,5	4,0	4,5	5,0	5,5	6,0	6,3	6,5	7,0	7,1	7,5	8,0	8,5	9,0	9,5*	10,0*
40	30	O/□	○	○														
50	30	O/□	○	○	○	○												
60	30	O/□	○	○	○	○												
60	40	□	□	□	□	□	○*	○*	○**									
70	40	□	□	□	□	□	○*	○*	○**									
80	40	□	□	□	□	□	○*	○*	○**									
80	50	□	□	□	□	□	□	□	□									
80	60	□	□	□	□	□	□	□	□									
90	50	□	□	□	□	□	□	□	□									
100	50	□	□	□	□	□	□	□	□									
100	60	□	□	□	□	□	□	□	□									
100	80	□	□	□	□	□	□	□	□	□	□	□	□	□				
110	60	□	□	□	□	□	□	□	□									
120	60	□	□	□	□	□	□	□	□									
120	80	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	○	○	○	○
140	70	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	○	○	○	○
140	80	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	○	○	○	○
150	50	□	□	□	□	□	□	□	□									
150	75	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	○	○	○	○
150	100	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	O/□	○	○	○	○
160	80	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
160	90	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
180	100			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
200	100			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
200	120			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
200	150			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
220	120			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
250	150			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
260	140			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
260	180								○	○	○	○	○	○	○	○	○	○

Surface unpickled	upon request	Forming Technologies ○ Round tube forming   □ Direct forming   O/□ Both available
-------------------	--------------	--

\* For steel grades up to S550M

\*\* For steel grades up to S500M



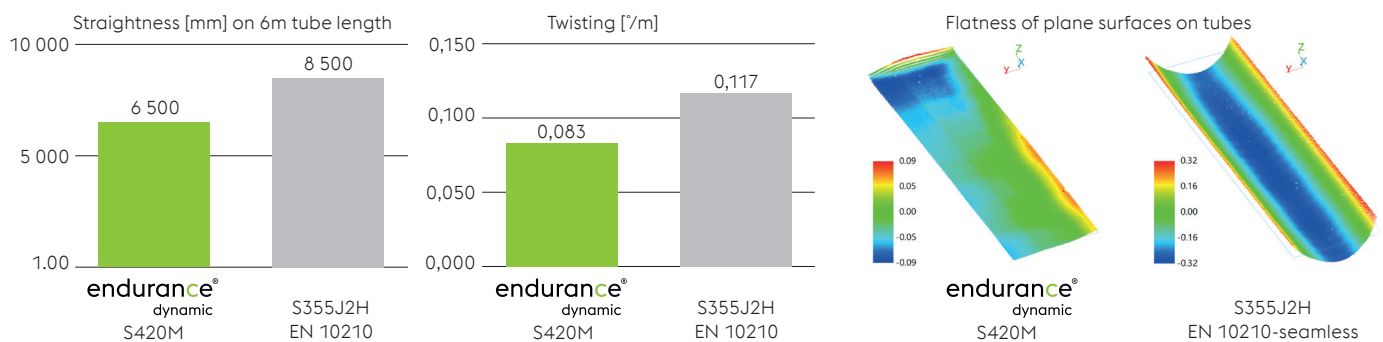
# PROCESSABILITY AND MECHANICAL CHARACTERISTICS

## EXCELLENT PROCESSABILITY

The very good degree of purity and the specially adjusted homogeneous microstructure of the steel grades used result in improved formability. In combination with adapted tube manufacturing, this offers advantages when expanding and bending the tubes. In addition, narrow chamfer dimensions can be realized.

- » Compared to EN10219, narrower chamfer dimensions are made possible - up to  $1.25 \times T$
- » Dimensional tolerances from EN10219 can be limited

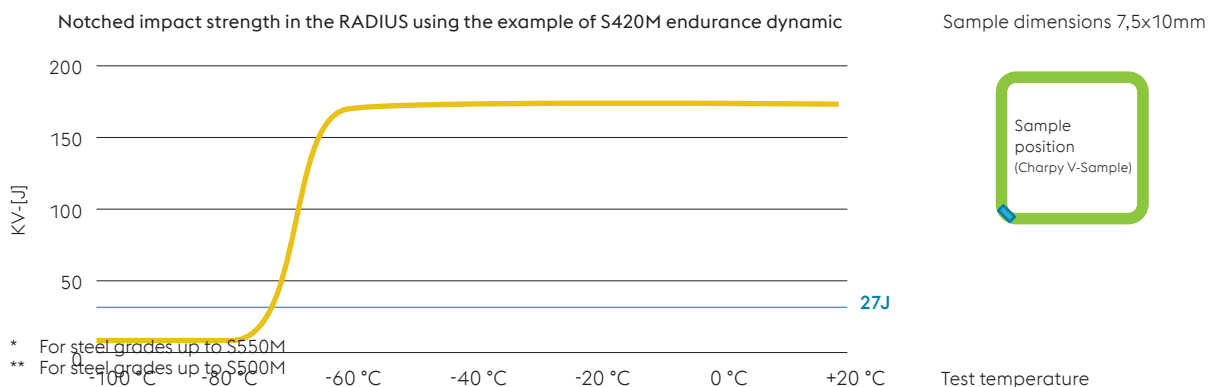
endurance dynamic is known for its high quality in straightness, twisting and flatness of plane surfaces. Especially in the automated processing of hollow sections there are advantages in manipulation. In addition, fewer imperfections occur, which in turn leads to a reduction in instability under compressive loads.



## MECHANICAL CHARACTERISTICS

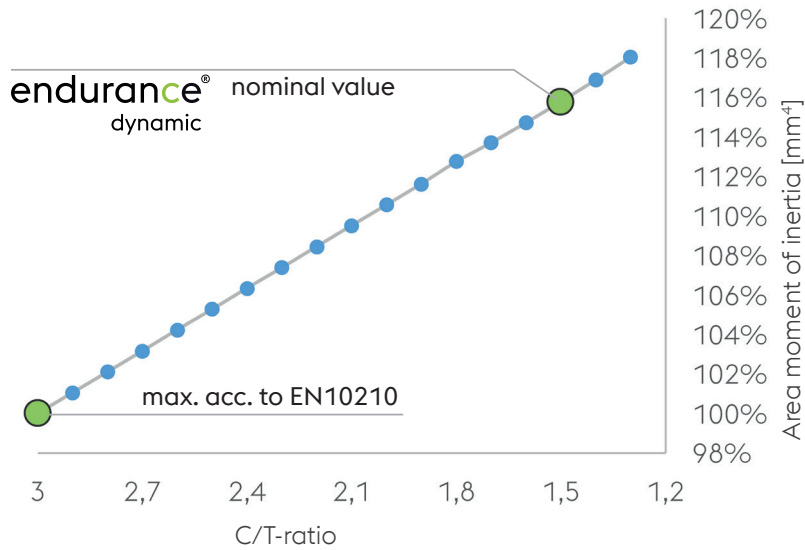
endurance dynamic meets all material requirements of EN10149-2. The very good degree of purity and the specially adjusted homogeneous microstructure also improve formability and notched impact strength.

Verified notched bar impact values of **27J at -40°C in longitudinal direction up to incl. S600M**



## CHAMFER DIMENSIONS AND STIFFNESS

I to C/T-ratio using sample 100/100x10

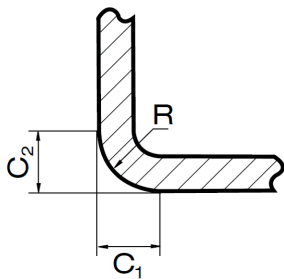


Compared to EN 10219, **narrower chamfer dimensions - up to 1.25 x T** - are possible.

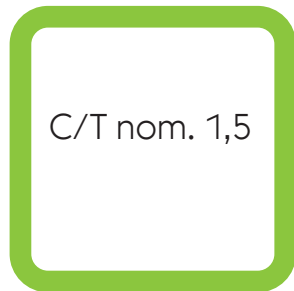
A smaller chamfer dimension improves the weldability and increases the area moment of inertia I [mm<sup>4</sup>] or the tube stiffness.

This makes endurance dynamic mechanically more resilient while maintaining the same external dimensions.

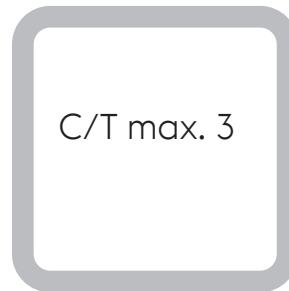
Chamfer dimensions  
 $C_1, C_2$



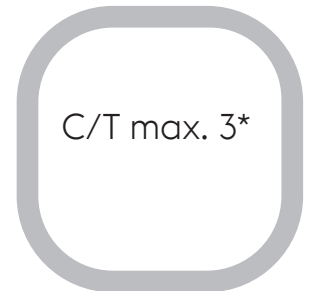
**endurance<sup>®</sup>**  
dynamic



Hollow section acc.  
**EN 10210-seamless**



Hollow section acc.  
**EN 10219**



\* Edge dimensions depending on the nominal wall thickness

## WELDABILITY

### EXCELLENT WELDABILITY OF THE BASE MATERIAL

For endurance dynamic, a micro-alloyed, thermomechanically rolled steel (SxxxM) with a particularly low content of carbon (C), phosphorus (P), sulphur (S) and nitrogen (N) is used. Due to the low content of these elements, which are disadvantageous for welding processing, the weldability of the used base material is excellent.

In this context, it should be explicitly mentioned that even in the radius area, welding can be performed without limitations. Hydrogen embrittlement, microstructure hardening and ageing phenomena are thus reduced to a negligible degree. Preheating is generally not necessary due to the low carbon content.

#### Typical alloy content

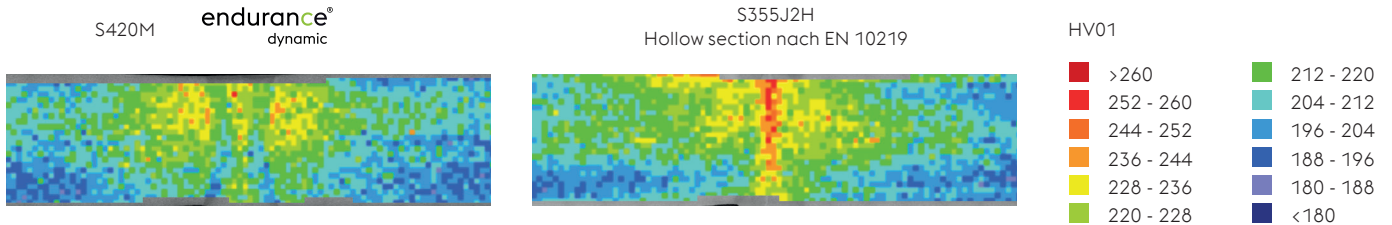
Figures in (%)

	C	P	S	N
<b>S420M</b> endurance dynamic, example	<b>0,078</b>	<b>0,007</b>	<b>0,001</b>	<b>0,004</b>
<b>S420MC</b> (EN10149-2), acc. to standard	≤ 0,12	≤ 0,025	≤ 0,015	-
<b>S355J2H</b> (EN 10219), typical value	0,170	0,012	0,004	0,005
<b>S355J2H</b> (EN 10210), typical value	0,160	0,015	0,002	0,005



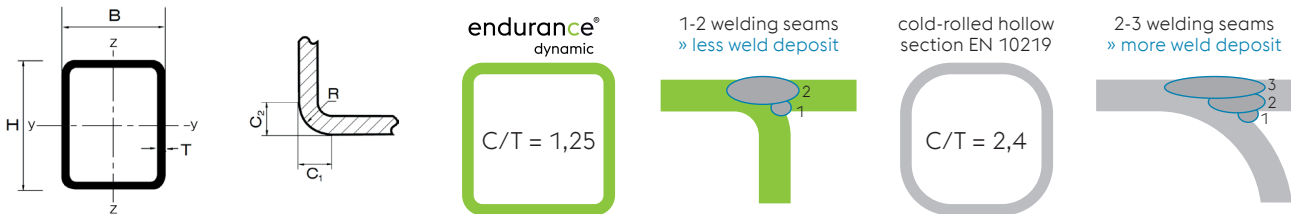
## HOMOGENEOUS LONGITUDINAL WELD SEAM

Low carbon contents ensure that there is less hardening in the weld seam. This results in a homogeneous hardness profile across the weld seam and the formation of a metallurgical notch is reduced, resulting in improved fatigue strength.



## EFFICIENT WELDING

A very good degree of purity and the specially adjusted homogeneous microstructure further improve formability. A C/T ratio of up to 1.25 can consequently be achieved.



Calculation example: 100mm long weld seam, pipe joint, hollow profile 100x100x8mm

	Hollow section EN 10219	endurance <sup>®</sup> dynamic
Erforderliches Nahtvolumen	13,8 cm <sup>3</sup>	7,8 cm <sup>3</sup>
Erforderliche Anzahl an Lagen	3	2
Gesamte Schweißzeit	1,4 min	0,6 min

By using endurance dynamic with a narrow chamfer of the radii, a reduction of 43% in filler metal and 56% in actual welding time can be achieved.

## WELDING PROCESSING RECOMMENDATIONS

Material	Process	Filler material solid wire (135)	Filler material cored wire (136)	Shielding gas	Preheating [°C]	Interpass temperatures [°C]	t8/5-Range4 [s]
S355M	GMAW	E.G. BÖHLER EMK 6, UNION K 52, ... ER70S-6 (ACC. AWS A5.18)	E.G. BÖHLER HL 46-MC, BÖHLER TI 52-FD, ... E70T15, E71T1 (ACC. AWS A5.36)	M21 (Z.B. CORGON 18, ...)	---1), 2)	---3)	5 - 25
S420M S460M S500M S550M	GMAW	e.g. BÖHLER NiMo 1-IG, UNION MoNi, ... ER90S-G (acc. AWS A5.28)	e.g. BÖHLER HL 53T-MC, BÖHLER Ti 60T-FD, ... E80T15, E81T1 (acc. AWS A5.36)	M21 (z.B. Corgon 18, ...)	---1), 2)	---3)	5 - 25
S600M	MAG	e.g. BÖHLER NiCrMo 2,5-IG, ... ER110S-G (acc. AWS A5.28)	e.g. BÖHLER HL 75T-MC, BÖHLER Ti 80T-FD, ... E101T15, E111T1 (acc. AWS A5.36)	M21 (e.g. Corgon 18, ...)	---1), 2)	---3)	5 - 25

- 1) Depending on atmospheric conditions (temperature below dew point, condensation) edge drying is recommended at least 80 °C immediately before welding.
- 2) In complex welded construction (e.g. out of position welding, accumulation of welds, ...) preheating according to EN 1011-2 is recommended.
- 3) It is recommended that the interpass temperature is adjusted in such a manner, that the maximum measured t8/5 time is not exceeded.
- 4) Cooling time between 800°C and 500°C, measured according to EN 1011-2 (Appendix D.8)

# FATIGUE STRENGTH

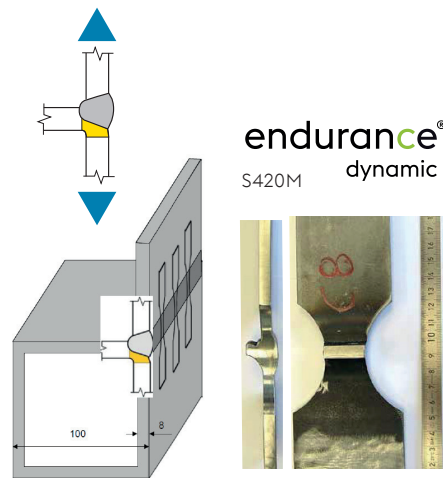
## IMPROVED FATIGUE STRENGTH

In many applications, rectangular and square tubes are welded to form a truss or framework, for example for agricultural equipment or crane booms. Under cyclic loads, geometric and metallurgical notch effects are the main determinants of fatigue strength in most applications.

**In the case of endurance dynamic, the geometric notch effect is reduced by a narrower C/T ratio and the metallurgical notch effect is lowered by the use of thermomechanically rolled steel.**

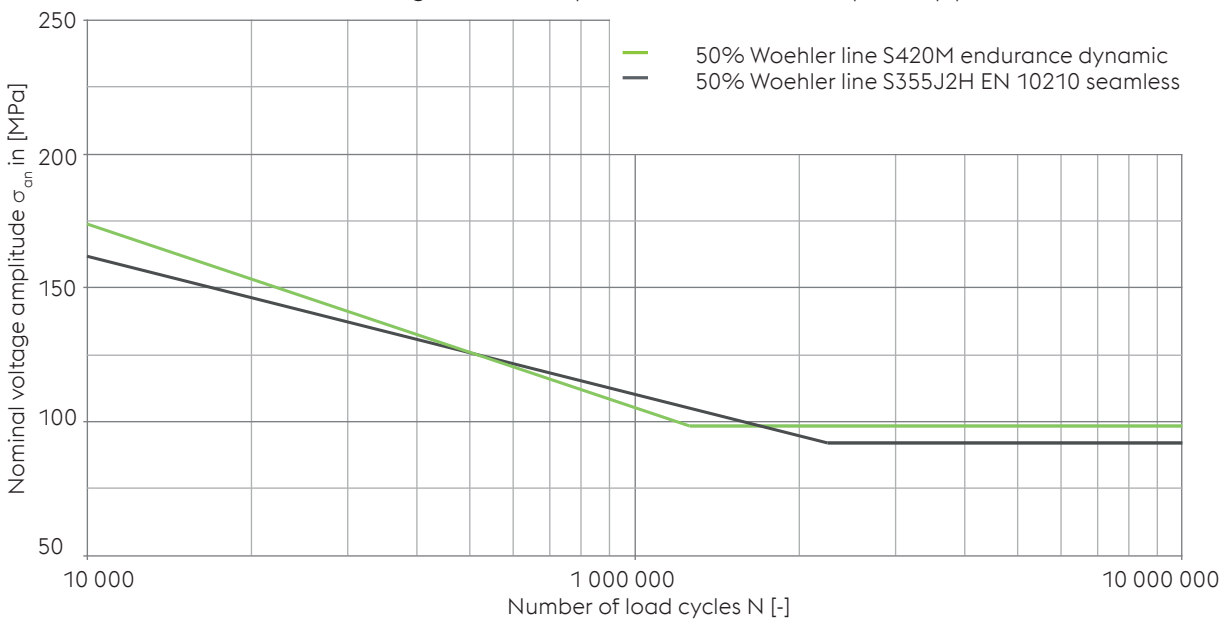
To illustrate the product's good properties, welded sample assemblies were subjected to a dynamic load test.

Regardless of the manufacturing route, the Woehler lines show **almost identical vibration resistance characteristics**, both in time and in the fatigue strength range.



Weld filler material: Böhler EMK8

Woehler diagram - fracture position: transition weld deposit to pipe







# APPLICATIONS IN AGRICULTURAL MACHINERY





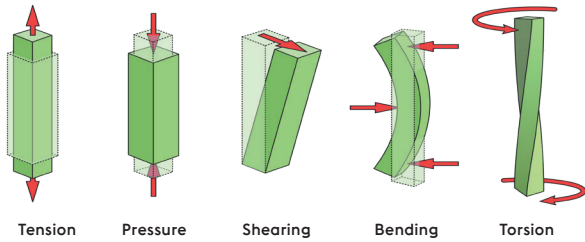
## DYNAMIC LOAD TESTS ON THE BASE TUBE

For independent and extended characterization of endurance dynamics, representative tests were developed with a university based on typical loads on the tube.

The fatigue behavior of endurance dynamics compared with hot-finished tubes according to EN 10210 was the focal point.

## FATIGUE STRENGTH BASE TUBE

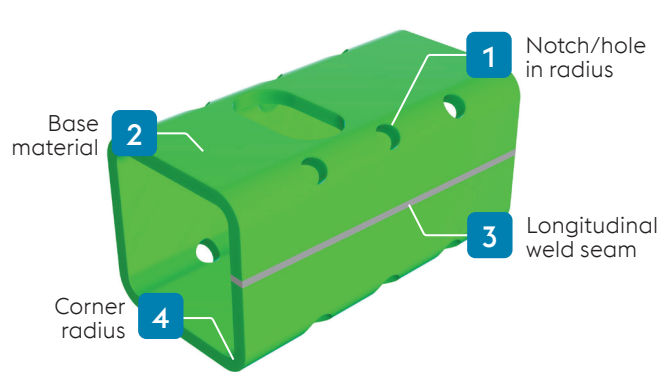
### LOAD TYPES



### DIAGRAM-LEGEND

- 50% Woehler line S420M endurance dynamic
- 50% Woehler line S355J2H EN 10210 welded
- 50% Woehler line S355J2H EN 10210 seamless

### LOCATION OF THE SAMPLES

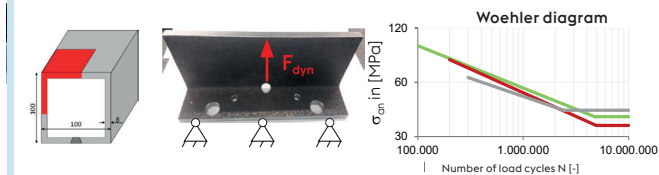


### NOTCH/HOLE IN THE RADIUS

1

#### Study objectives

- » Impact of notch effect in the radius / near the radius
- » Difference in manufacturing method COLD/HOT formed



#### Results

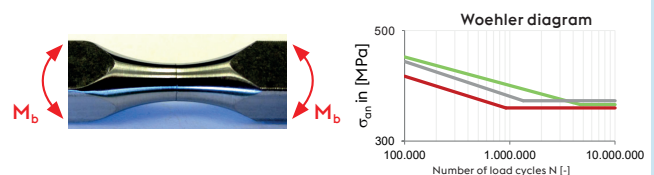
- » All three tube designs show almost identical behavior
- » endurance dynamic at least equivalent to tubes according to EN 10210

### BASE MATERIAL

2

#### Study objectives

- » Impact of base material (longitudinal & transverse)
- » Difference in manufacturing method COLD/HOT formed



#### Results

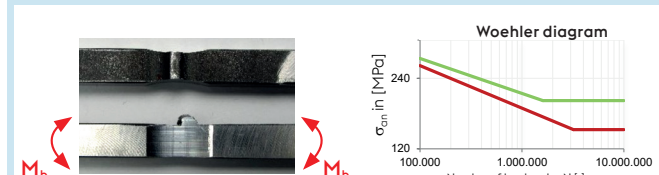
- » The Woehler line "EN 10210 welded" limits the scatter band downwards
- » The three base materials are viewed as equivalent, although S420M is slightly better

### LONGITUDINAL WELD SEAM

3

#### Study objectives

- » Impact of heat treatment on longitudinal weld seam
- » Difference in manufacturing method COLD/HOT formed



#### Result-

ts

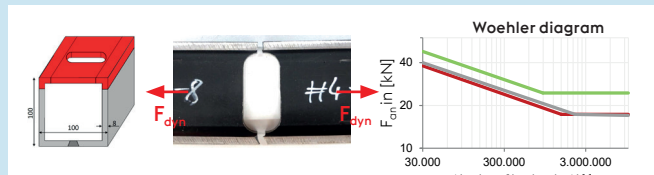
- » The Woehler line "EN 10210 welded" limits the scatter band downwards
- » endurance dynamic shows slightly better behavior in the transitional area

### CORNER RADIUS

4

#### Study objectives

- » Impact of strain hardening in the radius
- » Difference in manufacturing method COLD/HOT formed



#### Results

- » The Woehler lines run almost parallel
- » All three tubes show similar behavior
- » endurance dynamic slightly above



endurance<sup>®</sup>  
extreme



# RELY ON A COMPELLING POWERFUL SOLUTION!

Highly demanding requirements need powerful performance: **endurance extreme** hollow and special sections made from high-strength steel grades are singularly sturdy and tough, permitting a radical reduction of wall thickness and a significant reduction in weight. These robust section solutions are able to withstand even the harshest everyday conditions and static stresses.

## MECHANICAL PROPERTIES

Steel grade	Yield strength $R_{eH}$ [MPa]	Tensile strength $R_m$ [Mpa]	Elongation at break A [%] (up to 3mm) <sup>a)</sup>	Notched bar impact work [J] at test temperature -20° C
S500MH	500	580 to 760	11	40
S550MH	550	600 to 760	10	27
S600MH	600	650 to 820	9	27
S650MH	650	700 to 880	8	27
S700MH	700	750 to 950	7	27
S900MH	900	930 to 1200	5	27
S960MH	960	980 to 1250	4	27

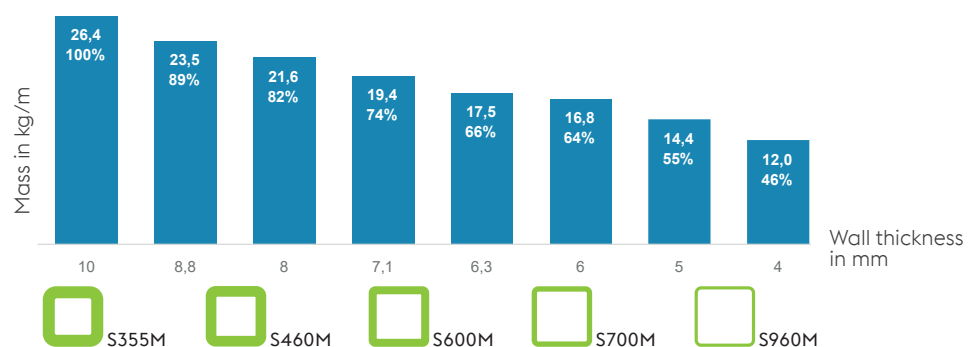
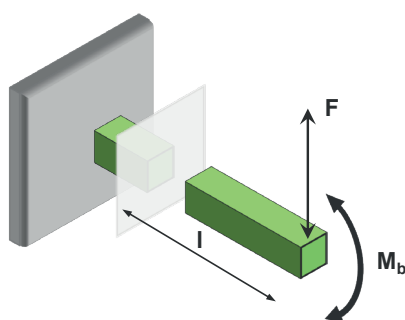
a) For wall thicknesses  $\geq 3$  mm and for profile ratios  $D/T \leq 10$  (circular) and  $(B+H)/2T \leq 10$  (square and rectangular), the minimum elongation value has to be reduced by 4 and the maximum tensile strength has to be increased by 50 MPa.

For profile ratios  $D/T > 10$  to  $< 15$  (circular) and  $(B+H)/2T > 10$  to  $< 15$  (square and rectangular), the minimum elongation value has to be reduced by 2 and the maximum tensile strength has to be increased by 50 MPa.

## LIGHTWEIGHT CONSTRUCTION BY REDUCING WEIGHT

By using **high-strength steel grades**, weight savings can be achieved while fully retaining the load-bearing capacity. This allows the **mass to be reduced by up to 54%**.

Example: Alternately loaded, clamped bending beam 100/100







# EXTREME SAFETY ADVANTAGES

## OUTSTANDING EASE OF PROCESSING AND MACHINING

Despite their high degree of sturdiness, endurance extreme hollow sections boast excellent forming characteristics and weldability and are easy to cut and stamp.

## SERIOUS REDUCTION IN WEIGHT

Higher-strength hollow sections can reduce the total weight of parts by up to a third while ensuring the same degree of resilience. This means increased payloads and capacities for containers, cranes and trucks as well as lower fuel consumption for vehicles and allows unique designs and visual design effects, for example in facade engineering.

## INCREASED SAFETY

When compared to conventional steel grades, higher-strength hollow sections can boost stability by up to 60% at unchanged wall thicknesses while improving fatigue behavior, thus optimizing safety in many different areas of application.



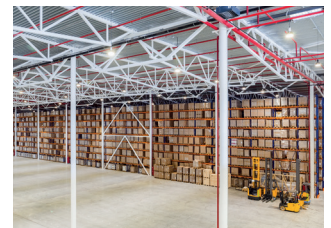
» Crane construction



» Automotive production



» Bus construction



» Storage systems



# GALVANIZING CLASS AND CE LABELING

## GALVANIZING CLASS

For batch galvanizing according to the application standard „ISO 1461: Requirements and tests“, galvanizing class 1 or category A according to ISO 14713-2 can be certified for tubes according to the endurance dynamic factory standard.

This applies to the grades

- » S355M
- » S420M
- » S460M
- » S500M
- » S550M\*

Attention is drawn to the fact that galvanizing-compatible constructions (drain holes, tightly welded cavities) must be ensured. ISO 14713 is to be observed as a guideline for the protection of steel structures against corrosion.

\*) Materials above S500 are subject to a separate process test for hot-dip galvanizing (see DaSt Guideline 022 - „Hot-dip galvanizing of load-bearing steel components“). Tests carried out in accordance with DaSt 022 on endurance dynamic hollow section samples made of S420M with narrow chamfer dimensions ( $C/T=1.25$ ) indicated no noticeable deviations.

## CE-LABELING

CE labeling is an essential basis for endurance to be placed on the market as a construction product throughout the European Union. It declares the conformity of our endurance hollow profiles with the applicable standards.

endurance dynamic hollow sections are produced in accordance with drawings and standards and can be CE labeled for use in steel structures in accordance with EN 1090-1 and EN 1090-4 EXC2.

# WALKING THE PATH TOGETHER

In a world of constant change, we are proud to be a reliable anchor for our customers. For more than 80 years, voestalpine Krems has been known for quality, reliability, stability and sustainability.

## **Ready for the future**

We fully believe in the power of long-term relationships. Our customers are not transactions, they are partners we grow with. Decades of cooperation and joint developments have taught us that trust and reliability are the key to sustainable success.

## **Quality that stands out**

Our customers rely on us, and for good reason. Our products meet the highest standards. With our state-of-the-art production facilities and our expertise in steel processing, we manufacture products that meet the most demanding requirements. **Quality is not an option - it is our commitment to you.**

## **Your goals are our goals**

We understand your needs and work closely with you to develop tailored solutions. **Our partnership approach ensures that we not only meet your expectations, but exceed them.**





# DISCOVER THE POSSIBILITIES



Visit our website for more information.  
We are looking forward to your inquiries.

**voestalpine Krems GmbH**  
Schmidhüttenstraße 5  
Postfach 43, 3500 Krems an der Donau, Austria  
T: +43/50304/14-0  
[www.voestalpine.com/endurance](http://www.voestalpine.com/endurance)

**voestalpine**  
ONE STEP AHEAD.