



Raex® wear-resistant steel

Raex® is high-strength and wear-resistant steel with favourable hardness and impact toughness. The plate thicknesses range now from 2 mm up to 80 mm providing a solution to all wear needs. With Raex wear plate you can extend the lifespan of machinery, decrease wear in structural components and save costs. Raex steel grades also enable innovative design and lightweight products improving energy efficiency and lowering fuel costs. Raex is utilised in various applications of mechanical engineering by, for example, the automotive, heavy lifting and transportation, and mining industries.

Applications

- Buckets and containers
- Cutting edges for earth moving machines
- Wear parts for mining machines
- Wear parts for concrete mixing plants and wood processing machines
- Platform structures
- Feeders, funnels
- Tipper bodies

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Dimensions

Cut lengths with mill edges

Ruukki Raex	Thickness mm	Width mm	Length m
Raex 300	2.0 - 8	1000 - 1550 ¹⁾	2 - 12 ²⁾
Raex 400	2.0 - 8	1000 - 1750 ¹⁾	2 - 12 ²⁾
Raex 450	2.5 - 8	1000 - 1700 ¹⁾	2 - 12 ²⁾
Raex 500	3.0 - 6.5	1000 - 1525 ¹⁾	2 - 12 ²⁾

¹⁾ Maximum width of a cut length depends on the thickness and steel grade.

²⁾ Cut lengths with lengths 12-13 metres are available subject to special agreement.

Heavy plates

Ruukki Raex	Thickness range mm	Width mm	Length m
400/450/500	6 - 40	1800 - 3200 ¹⁾	2 - 12 ²⁾
400/450/500	40.01 - 60 ³⁾	2000 - 2400	4 - 9,5 ⁴⁾
400/450/500	40.01 - 60 ³⁾	2401 - 2500	4 - 9 ⁴⁾
400/450/500	60.01 - 80 ³⁾	2000 - 2400	4 - 6,9 ⁴⁾
400/450/500	60.01 - 80 ³⁾	2401 - 2500	4 - 6,5 ⁴⁾

¹⁾ Minimum and maximum width of a heavy plate depend on the thickness.

²⁾ Plates with lengths 12-16 metres are available subject to special agreement.

³⁾ In thicknesses of 40.01 – 80 mm the maximum plate weight is 10 tons instead of 11 tons which is possible for thicknesses < 40 mm.

⁴⁾ In case of 2000 – <4000 mm of minimum length, two plates is the minimum amount to be ordered.

Other dimensions are available subject to special agreement only.

Plate width 1000mm - 1600mm is possible in thickness range 10 - 80mm respecting maximum and minimum lengths is given table. Number of the ordered pieces must be double.

Tolerances

Cut lengths

- Thickness EN 10051:2010 category A
- Width and length EN 10051
- Flatness EN 10029 Class N normal tolerances on flatness, steel type H.

Heavy plates

- Thickness EN 10029 Class A
- Width and length EN 10029
- Flatness EN 10029, Class N normal tolerances on flatness, steel type H.

Surface quality

Cut lengths are delivered in as-rolled condition.

Heavy plates can be delivered as-rolled or in shop-primed condition.

Surface quality: EN 10163-2 Class A3.

Properties

Delivery condition

The delivery condition of Raex steel is hardened.

Hardness values

Ruukki Raex	Thickness mm	Hardness (HBW)	Product shape
Raex 300	2.0 - 8.0	270 - 390	Cut lengths
Raex 400	2.0 - 8.0	360 - 440	Cut lengths
Raex 400	6 - 80	360 - 440	Heavy plates
Raex 450	2.5 - 8	420 - 500	Cut lengths
Raex 450	6 - 80	420 - 500	Heavy plates
Raex 500	3.0 - 6.5	450 - 540	Cut lengths
Raex 500	6 - 80	450 - 540	Heavy plates

Materials testing

Hardness is measured in Brinell units (HBW) in compliance with EN ISO 6506-1 on a milled surface 0.3–2 mm below plate surface. The measurement depth is determined on the basis of product form and plate thickness.

Typical mechanical properties

Ruukki Raex	Yield strength R _{p0.2} MPa	Tensile strength R _m MPa	Elongation A%	Impact strength Charpy V 30 J
Raex 300	900	1000	11	- 40°C
Raex 400	1000	1250	10	- 40°C
Raex 450	1200	1450	8	- 40 °C
Raex 500	1250	1600	8	- 40°C

Chemical composition

Content % maximum (cast analysis). The steel is grain refined.

Ruukki Raex	C	Si	Mn	P	S	Cr	Ni	Mo	B
Raex 300	0.18	0.80	1.70	0.025	0.015	1.50	1.00	0.50	0.005
Raex 400	0.23	0.80	1.70	0.025	0.015	1.50	1.00	0.50	0.005
Raex 450	0.26	0.80	1.70	0.025	0.015	1.50	1.00	0.50	0.005
Raex 500	0.30	0.80	1.70	0.025	0.015	1.50	1.00	0.50	0.005

Typical carbon equivalent values

$$CEV = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15 \quad CET = C + Mn/10 + Mo/10 + Cr/20 + Cu/20 + Ni/40$$

Ruukki Raex	Thickness mm	CEV ¹⁾	CET ²⁾	Product shape
Raex 300	2.0 - 8.0	0.46	0.24	Cut length
Raex 400	2.0 - 4.0	0.48	0.29	Cut length
Raex 400	4.01 - 8.0	0.53	0.31	Cut length
Raex 400	6 - 20	0.42	0.28	Heavy plate
Raex 400	20.01 - 30	0.50	0.32	Heavy plate
Raex 400	30.01 - 40	0.56	0.34	Heavy plate
Raex 400	40.01 - 80	0.57	0.35	Heavy plate
Raex 450	2.5 - 8	0.52	0.35	Cut length

Ruukki Raex	Thickness mm	CEV ¹⁾	CET ²⁾	Product shape
Raex 450	6 - 30	0.47	0.34	Heavy plate
Raex 450	30.01 - 40	0.57	0.37	Heavy plate
Raex 450	40.01 - 80	0.64	0.37	Heavy plate
Raex 500	3 - 6.5	0.54	0.40	Cut length
Raex 500	6 - 40	0.57	0.40	Heavy plate
Raex 500	40.01 - 80	0.66	0.40	Heavy plate

¹⁾ The CEV value is being announced in the inspection certificate.

²⁾ The CET values are tabulated for information only.

Prefabrication services

Shop-primed plates

Shop priming gives steel temporary corrosion protection for the transport period, short-term storing and workshop processing. In engineering workshop operation it improves the cleanliness of working environment and occupational safety. Cutting and welding shopprimed plates is easy. Moreover, the adherence of spatters on the steel structure is significantly decreased.

Flat cut shapes

Using flat cut shapes, the manufacture and throughput time of installation will decrease. The customer will receive the needed components ready for installation, and can thus avoid unnecessary material and storing costs. If ordered, the products are delivered as shop-primed, bevelled and bent.

Processing instructions

Welding and thermal cutting

The weldability of Raex steels has been developed to the top class among wear-resistant steels on the market. Practical welding instructions for the Raex 400, Raex 450 and Raex 500 grades are presented on the separate technical brochure. Moreover, the brochure specifies the special features regarding thermal cutting of Raex steels.

Cold forming

Raex steels can be cold formed up to the thickness of 20 mm, see the table below. Forming temperature must be a minimum of +20°C and a maximum of +200°C.

Standard values for free bending and flanging. Thickness ≤20mm.

Ruukki Raex	Free bending < 90° Plunger radius or curvature / plate thickness R/t Bend line position vs. rolling direction		Gap width / plate thickness W/t		Bending to 90° V channel W/t
	Transverse	Longitudinal	Transverse	Longitudinal	
Raex 300	3	3	9	9	≈15
Raex 400	3	4	9	11	≈15
Raex 450	4	5	11	13	≈15
Raex 500	5	6	13	15	≈15

It is recommended to consult Ruukki Technical Customer Service when bending Raex 500 steel or plates thicker than 20 mm (0.787").

Heat treatment

Hardened steels are not intended to be heat treated. Tempering in the maximum temperature of +200 °C is the only heat treatment which will maintain the abrasion resistance properties of the plate at a good level. Heat treatment in higher temperatures decreases the strength, hardness and abrasion resistance properties of steels.

Drilling

Raex 400 and Raex 450 can be drilled with HSS drills. For drilling of Raex 500, hard metal drills are recommended. General instructions for drilling of wear-resistant steels are:

- The drilling machine has to be rigid and stable in order to minimize vibrations
- Clamp the work piece securely and close to the area to be machined
- Short-hole drills (DIN 1897) are recommended
- The service life of the drilling tool can be prolonged by decreasing the speed
- Provide an abundant supply of cutting fluid

Mechanical cutting

Hardened steels can be cut mechanically. This is, however, challenging because the plate is almost as hard as the cutting blade. High shear force is needed due to the high tensile strength of the steel. High surface pressures during cutting are directed at the blade, which increases wear. The most recommended cutting tool is a straight cutting tool.

The most important cutting parameters are blade clearance and blade angle. The hardness of the blade is of great importance. Raex 300/400/450 steels can be cut with heavy-duty cutting machines, but the hardness of the cutting blade must exceed 53 HRC. The mechanical cutting of Raex 500 steel can be recommended only with certain reservations, and then only at thicknesses of less than 10 mm and blade hardness over 57 HRC.

Mechanical cutting of Raex 400 steels, guideline values

Plate thickness mm t	Blade clearance mm U	Angle of tilt α°	Angle of skew λ°	Shearing force a x 10 ³ N
6	0.60 – 0.72	3 – 4	0 – 3	150 – 200
8	0.80 – 1.28	3 – 5	0 – 5	250 – 350
10	1.00 – 1.80	4 – 6	0 – 5	300 – 450
12	1.20 – 2.16	4 – 6	0 – 5	400 – 600

Occupational safety

Special care must be taken in all stages of handling hardened steels. Flanging is challenging due to the high strength and high flexural stresses of the plate. If the bending radius, for example, is too small and a crack is created in the bending point, the plate may fly from the bending tool in the direction of the bend.

Those bending the plate must take appropriate precautions to protect themselves and no unauthorised persons must be allowed in the area. The safest location is usually by the bending machine. The handling instructions of the steel supplier and safety instructions of the workshop must be adhered to in detail. New employees must receive appropriate training before they are allowed to process hardened steels.

Order & delivery

Delivery condition

The delivery condition of Raex steel is hardened.

Inspection document

On the customer's request, either a Test report 2.2 or Inspection certificate 3.1 in compliance with EN 10204 is granted to Raex steels. The inspection document states the chemical composition of steel based on cast analysis and hardness in delivery condition.

General delivery information for hot-rolled steels

General delivery information for hot rolled steels can be found from documents *Markings and packing*, *Ultra-sonic testing* and *General terms of sale*.

Technical information in imperial units

Dimensions

Cut lengths with mill edges

Ruukki Raex	Thickness inch	Width inch	Length inch
Raex 300	0.079" - 0.315"	39" - 61" ¹⁾	79" - 472" ²⁾
Raex 400	0.079" - 0.315"	39" - 69" ¹⁾	79" - 472" ²⁾
Raex 450	0.098" - 0.315"	39" - 67" ¹⁾	79" - 472" ²⁾
Raex 500	0.118" - 0.256"	39" - 60" ¹⁾	79" - 472" ²⁾

Heavy plates

Ruukki Raex	Thickness range inch	Width inch	Length inch
400/450/500	0.236" - 1.574"	71" - 126" ¹⁾	79" - 472" ²⁾
400/450/500	1.575" - 2.362" ³⁾	79" - 94"	157" - 374" ⁴⁾
400/450/500	1.575" - 2.362" ³⁾	94" - 157"	157" - 354" ⁴⁾
400/450/500	2.363" - 3.150" ³⁾	79" - 94"	157" - 272" ⁴⁾
400/450/500	2.363" - 3.150" ³⁾	94" - 157"	157" - 256" ⁴⁾

1) Minimum and maximum width of a heavy plate depend on the thickness.

2) Plates with lengths 472" - 630" are available subject to special agreement.

3) In thicknesses of 1.575" - 3.150" the maximum plate weight is 10 tons instead of 11 tons which is possible for thicknesses < 3.15".

4) In case of 79" - < 157" of minimum length, two plates is the minimum amount to be ordered.

Other dimensions are available subject to special agreement only.

Plate width 39.4" - 63.0" is possible in thickness range 0.394" - 3.15" respecting maximum and minimum lengths in given table. Number of the ordered pieces must be double.

Tolerances

Cut lengths

Thickness ASTM A6/A6M-12 Width and length ASTM A6/A6M-12 Flatness ASTM A6/A6M-12

Heavy plates

Thickness ASTM A6/A6M-12 Width and length ASTM A6/A6M-12 Flatness ASTM A6/A6M-12

Properties

Delivery condition

The delivery condition of Raex steels is hardened.

Hardness values

Ruukki Raex	Thickness inch	Hardness (HBW)	Product shape
Raex 300	0.079" - 0.315"	270 - 390	Cut lengths
Raex 400	0.079" - 0.315"	360 - 440	Cut lengths
Raex 400	0.236" - 3.150"	360 - 440	Heavy plates
Raex 450	0.098" - 0.315"	420 - 500	Cut lengths
Raex 450	0.236" - 3.150"	420 - 500	Heavy plates
Raex 500	0.118" - 0.256"	450 - 540	Cut lengths
Raex 500	0.236" - 3.150"	450 - 540	Heavy plates

Materials testing

Hardness is measured in Brinell units (HBW) in compliance with EN ISO 6506-1 on a milled surface 0.0118" – 0.079" below plate surface. The measurement depth is determined on the basis of product form and plate thickness.

Typical mechanical properties

Ruukki Raex	Yield strength	Tensile strength	Elongation A%	Impact strength	Impact strength
	Rp0,2 Ksi	Rm Ksi		Charpy V 30 J	Charpy V 22 ft/lbs
Raex 300	130 Ksi	140 Ksi	11	- 40°C	- 40°F
Raex 400	140 Ksi	180 Ksi	10	- 40°C	- 40°F
Raex 450	170 Ksi	210 Ksi	8	- 40°C	- 40°F
Raex 500	180 Ksi	230 Ksi	8	- 40°C	- 40°F

Chemical composition

Ruukki Raex	C	Si	Mn	P	S	Cr	Ni	Mo	B
Raex 300	0.18	0.8	1.7	0.025	0.015	1.5	1	0.5	0.005
Raex 400	0.23	0.8	1.7	0.025	0.015	1.5	1	0.5	0.005
Raex 450	0.26	0.8	1.7	0.025	0.015	1.5	1	0.5	0.005
Raex 500	0.3	0.8	1.7	0.025	0.015	1.5	1	0.5	0.005

Typical carbon equivalent values

$$CEV = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15 \quad CET = C + Mn/10 + Mo/10 + Cr/20 + Cu/20 + Ni/40$$

Ruukki Raex	Thickness inch	CEV ¹⁾	CET ²⁾	Product shape
Raex 300	0.079" - 0.315"	0.46	0.24	Cut length
Raex 400	0.079" - 0.157"	0.48	0.29	Cut length
Raex 400	0.157" - 0.315"	0.53	0.31	Cut length
Raex 400	0.236" - 0.787"	0.42	0.28	Heavy plate
Raex 400	0.787" - 1.181"	0.5	0.32	Heavy plate
Raex 400	1.181" - 1.57"	0.56	0.34	Heavy plate
Raex 400	1.57" - 3.15"	0.57	0.35	Heavy plate
Raex 450	0.098" - 0.315"	0.52	0.35	Cut length
Raex 450	0.236" - 1.181"	0.47	0.34	Heavy plate
Raex 450	1.181" - 1.57"	0.57	0.37	Heavy plate
Raex 450	1.57" - 3.15"	0.64	0.37	Heavy plate
Raex 500	0.118" - 0.256"	0.54	0.4	Cut length
Raex 500	0.236" - 1.57"	0.57	0.4	Heavy plate
Raex 500	1.57" - 3.15"	0.66	0.40	Heavy plate

Processing instructions

Welding and thermal cutting

The weldability of Raex steels has been developed to the top class among wear-resistant steels on the market. Practical welding instructions for the Raex 400, Raex 450 and Raex 500 grades are presented on the separate technical brochure. Moreover, the brochure specifies the special features regarding thermal cutting of Raex steels.

Cold forming

Raex 300/400/450 steels can be cold formed up to the thickness of 0.787", see the table below. Forming temperature must be a minimum of +86°F and a maximum of +392°F.

Standard values for free bending and flanging. Thickness ≤ 0.787".

Ruukki Raex	Free bending < 90° Plunger radius or curvature / plate thickness R/t Bend line position vs. rolling direction		Gap width / plate thickness W/t		Bending to 90° V channel W/t
	Transverse	Longitudinal	Transverse	Longitudinal	
Raex 300	3	3	9	9	≈15
Raex 400	3	4	9	11	≈15
Raex 450	4	5	11	13	≈15
Raex 500	5	6	13	15	≈15

Heat treatment

Drilling

Raex 400 and Raex 450 can be drilled with HSS drills. For drilling of Raex 500, hard metal drills are recommended. General instructions for drilling of wear-resistant steels are:

- The drilling machine has to be rigid and stable in order to minimize vibrations
- Clamp the work piece securely and close to the area to be machined
- Short-hole drills (DIN 1897) are recommended
- The service life of the drilling tool can be prolonged by decreasing the speed
- Provide an abundant supply of cutting fluid

Mechanical cutting

Hardened steels can be cut mechanically. This is, however, challenging because the plate is almost as hard as the cutting blade. High shear force is needed due to the high tensile strength of the steel. High surface pressures during cutting are directed at the blade, which increases wear. The most recommended cutting tool is a straight cutting tool.

The most important cutting parameters are blade clearance and blade angle. The hardness of the blade is of great importance. Raex 300/400/450 steels can be cut with heavy-duty cutting machines, but the hardness of the cutting blade must exceed 53 HRC. The mechanical cutting of Raex 500 steel can be recommended only with certain reservations, and then only at thicknesses of less than 0.394" and blade hardness over 57 HRC.

Mechanical cutting of Raex 400 steels, guideline values

Plate thickness inch t	Blade clearance inch U	Angle of tilt α°	Angle of skew λ°	Shearing force a x 103 N
0.236"	0.0236" – 0.0283"	3 – 4	0 – 3	150 – 200
0.315"	0.0315" – 0.0504"	3 – 5	0 – 5	250 – 350
0.394"	0.0394" – 0.0709"	4 – 6	0 – 5	300 – 450

Mechanical cutting of Raex 400 steels, guideline values

Plate thickness inch t	Blade clearance inch U	Angle of tilt α°	Angle of skew λ°	Shearing force a x 103 N
0.472"	0.0472" – 0.0850"	4 – 6	0 – 5	400 – 600

Occupational safety

Special care must be taken in all stages of handling hardened steels. Flanging is challenging due to the high strength and high flexural stresses of the plate. If the bending radius, for example, is too small and a crack is created in the bending point, the plate may fly from the bending tool in the direction of the bend.

Those bending the plate must take appropriate precautions to protect themselves and no unauthorised persons must be allowed in the area. The safest location is usually by the bending machine. The handling instructions of the steel supplier and safety instructions of the workshop must be adhered to in detail. New employees must receive appropriate training before they are allowed to process hardened steels.