

| | |
|------------------------|-------------------------|
| Quality | C45E |
| According to standards | EN 10083-2: 2006 |
| Number | 1.1191 |

Chemical composition

| C% | Si% | Mn% | P% | S% | Cr% | Mo% | Ni% | |
|-----------|--------|-----------|---------|---------|------|------|------|--------------------------------|
| 0,42-0,50 | 0,40 | 0,50-0,80 | 0,030 | 0,035 | 0,40 | 0,10 | 0,40 | Product deviations are allowed |
| ± 0.02 | + 0.03 | ± 0.04 | + 0.005 | + 0.005 | | | | |

Cr+Mo+Ni max 0.63%

For C45R n° 1.1201, S% 0.020-0.040 product deviation ± 0.005

For C45 n° 1.0503, P% - S% max 0.045

On request, it may be supplied (Ca) treated and with the addition of lead Pb 0.15-0.35%

Temperature °C

| Hot-forming | Normalizing +N | Quenching +Q | Quenching +Q | Tempering +T | Stress-relieving +SR | | |
|--|--|------------------|-------------------------------|---------------------|--|------------------|------------------|
| 1100-850 | 870 air | 840 water | 860 oil or polymer | 540-660 air | 50° under the temperature of tempering | | |
| Soft annealing +A | Isothermal annealing +I | Natural state +U | End quench hardenability test | Pre-heating welding | Stress-relieving after welding | | |
| 690 cooling 10 °C/h to 600, then air (HB max 207) | 810 furnace cooling to 660, then air (HB 160-216) | | 850 water | 250 | 550 furnace cooling | | |
| | | (~ HB 169-245) | | Ac1 735 | Ac3 780 | Ms 350 | Mf 120 |

Mechanical properties

C45E C45R Hot-rolled mechanical properties in normalized condition EN 10083-2: 2006

| size d / t | | Testing at room temperature (longitudinal) | | | | | |
|------------|---------|--|------------------------|------|------|--------|-----|
| mm | | R | Re ^{a)} | A% | C% | Kv | HB |
| from | to | N/mm ² min | N/mm ² min. | min. | min. | J min. | min |
| | 16/16 | 620 | 340 | 14 | | | 190 |
| 16/16 | 100/100 | 580 | 305 | 16 | | | 172 |
| 100/100 | 250/250 | 560 | 275 | 16 | | | 162 |

d = diameter t = thickness

C45E C45R Hot-rolled mechanical properties in quenched and tempered condition EN 10083-2: 2006

| size d / t | | Testing at room temperature (longitudinal) | | | | | |
|------------|--------|--|-----------------------|------|------|-------|-----------------|
| mm | | R | Re ^{a)} | A% | C% | Kv | HB |
| from | to | N/mm ² | N/mm ² min | min. | min. | J min | for information |
| | 16/8 | 700-850 | 490 | 14 | 35 | | 213-253 |
| 16/8 | 40/20 | 650-800 | 430 | 16 | 40 | 25 | 200-240 |
| 40/20 | 100/60 | 630-780 | 370 | 17 | 45 | 25 | 192-232 |

^{a)} Re upper yield strength or, if no yield phenomenon occurs, Rp 0.2 has to be considered

d = diameter t = thickness

Table of tempering values obtained at room temperature on rounds of Ø 10 mm after quenching at 850 °C in water

| °C | R N/mm ² | HRC | HB |
|-----|---------------------|--------------------------|-----|
| 100 | 2330 | 58 | 615 |
| 200 | 2240 | 57 | 597 |
| 300 | 1880 | 52 | 510 |
| 400 | 1390 | 43 | 401 |
| 500 | 1030 | 33 | 311 |
| 600 | 810 | 23 | 242 |
| °C | R N/mm ² | Rp 0.2 N/mm ² | A % |
| 620 | 740 | 480 | 22 |
| 650 | 600 | 400 | 23 |
| 700 | 540 | 320 | 24 |

Hardness condition

on bars quenched in water

A = diameter 13 mm

B = diameter 25 mm

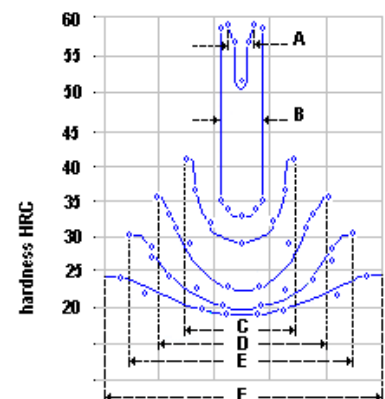
C = diameter 50 mm

D = diameter 75 mm

E = diameter 100 mm

F = diameter 130 mm

• hardness check points



C45E 1.1191 - C45R 1.1201

| Cold-drawn +C ^{c)} EN 10277-5: 2008 | | | | | | Hot-rolled + Peeled-Reeled +SH ^{c)} EN 10277-5: 2008 | | | |
|--|-----|--|-----------------------|-----|-------------|---|-----------------------|-----|---------|
| size mm | | Testing at room temperature (longitudinal) | | | | Testing at room temperature (longitudinal) | | | |
| from | to | R ^{a)} | Rp 0.2 ^{a)} | A% | HB | R | Rp 0.2 | A% | HB |
| | | N/mm ² | N/mm ² min | min | for inform. | N/mm ² | N/mm ² min | min | |
| 5 ^{b)} | 10 | 750-1050 | 565 | 5 | 225-319 | | | | |
| 10 | 16 | 710-1030 | 500 | 6 | 218-311 | | | | |
| 16 | 40 | 650-1000 | 410 | 7 | 200-298 | 580-820 | | | 172-242 |
| 40 | 63 | 630-900 | 360 | 8 | 192-271 | 580-820 | | | 172-242 |
| 63 | 100 | 580-850 | 310 | 8 | 172-253 | 580-820 | | | 172-242 |

^{a)} for flats and special sections, yield point can be -10% and tensile strength can be ± 10%

^{b)} for thickness < 5 mm, mechanical properties should be agreed before order placement

^{c)} values valid also for +C+SL and +SH+SL

| EN 10277-5: 2008 | | | | | | pr. ISO/CD 683-18: 2012 | | | |
|--|-----|--|-----------------------|-----|-------------|--|-----------------------|-----|-----------|
| Hot-rolled, quenched and tempered, cold-drawn +QT +C ^{c)} | | | | | | Cold-drawn + quenched and tempering +C +QT ^{c)} | | | |
| size mm | | Testing at room temperature (longitudinal) | | | | Testing at room temperature (longitudinal) | | | |
| from | to | R | Rp 0.2 | A% | HB | R | Rp 0.2 | A% | Kv +20 °C |
| | | N/mm ² | N/mm ² min | min | for inform. | N/mm ² | N/mm ² min | min | J min |
| 5 ^{b)} | 10 | 850-1050 | 595 | 8 | 253-319 | | | | |
| 10 | 16 | 810-1010 | 565 | 8 | 243-300 | | | | |
| 16 | 40 | 750-950 | 525 | 9 | 225-286 | 650-800 | 430 | 16 | 25 |
| 40 | 63 | 650-850 | 455 | 10 | 200-253 | 630-780 | 370 | 17 | 25 |
| 63 | 100 | 650-850 | 455 | 11 | 200-253 | 630-780 | 370 | 17 | 25 |

^{b)} for thickness < 5 mm, mechanical properties should be agreed before order placement

^{c)} values valid also for +QT+C+SL and +C+QT+SL

Testing at room temperature (longitudinal) **LUCEFIN** experience

| diameter mm | Cold-drawn +QT | | | | Cold-drawn + QT + Cold-drawn | | | |
|-------------|-------------------|-----------------------|------|------------|------------------------------|-----------------------|------|------------|
| | R | Rp 0.2 | A% | Kv + 20 °C | R | Rp 0.2 | A% | Kv + 20 °C |
| | N/mm ² | N/mm ² min | min | J | N/mm ² | N/mm ² min | min | J |
| 56 | 675 | 429 | 22,6 | 60-50-60 | 704 | 570 | 23,6 | 45-36-58 |

C45E 1.1191 Forged normalized EN 10250-2: 2001

| size mm | | Testing at room temperature | | | | | | | |
|---------|------|-----------------------------|-----------------------|-------|-------|-------|-----------|-----------|-----|
| from | to | R | Re ^{c)} | A% | A% | A% | Kv +20 °C | Kv +20 °C | HB |
| | | N/mm ² min | N/mm ² min | min L | min T | min Q | J min L | J min T | min |
| | 100 | 580 | 305 | 16 | | | | | 172 |
| 100 | 250 | 560 | 275 | 16 | 12 | | 18 | 10 | 162 |
| 250 | 500 | 540 | 240 | 16 | 12 | | 15 | 10 | 158 |
| 500 | 1000 | 530 | 230 | 15 | 11 | | 12 | 10 | 156 |

C45E 1.1191 Forged quenched and tempered EN 10250-2: 2001

| size d / t | | Testing at room temperature | | | | | | | |
|------------|---------|-----------------------------|-----------------------|-------|-------|-------|-----------|-----------|-----|
| from | to | R | Re ^{c)} | A% | A% | A% | Kv +20 °C | Kv +20 °C | HB |
| | | N/mm ² min | N/mm ² min | min L | min T | min Q | J min L | J min T | min |
| | 100/70 | 630 | 370 | 17 | | | 25 | | 192 |
| 100/70 | 250/160 | 590 | 340 | 18 | 12 | | 22 | 15 | 176 |
| 250/160 | 500/330 | 540 | 320 | 17 | 11 | | 20 | 12 | 158 |

L = longitudinal T = tangential Q = radial

^{c)} Re upper yield strength or, if no yield phenomenon occurs, Rp 0.2 has to be considered

d = diameter t = thickness

C45E C45R EN 10083-2: 2006 Jominy test HRC grain size 5 min.

| mm distance from quenched extremity | | | | | | | | | | | | | | | | | |
|-------------------------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|--------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 13 | 15 | 20 | 25 | 30 | H |
| min | 55 | 51 | 37 | 30 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | | | | normal |
| max | 62 | 61 | 61 | 60 | 57 | 51 | 44 | 37 | 34 | 33 | 32 | 31 | 30 | | | | |

| EUROPE | ITALY | CHINA | GERMANY | FRANCE | U.K. | RUSSIA | USA |
|--------|-------|-------|---------|--------|--------|--------|----------|
| EN | UNI | GB | DIN | AFNOR | B.S. | GOST | AISI/SAE |
| C45E | C45 | 45 | Ck45 | XC48 | 080M46 | 45 | 1045 |

C45E

| | | | | | | | | | |
|----------------------------------|---------------------------|---|-----------|------------|------------|------------|------------|------------|------------|
| Thermal Expansion | $10^{-6} \cdot K^{-1}$ | ► | 11.1 | 12.1 | 12.9 | 13.5 | 13.9 | 14.1 | |
| Mod. of Elasticity long. | | | 220 | 205 | 195 | 185 | 175 | | |
| Mod. of Elasticity tang. | | | 88 | 78 | 74 | 71 | 67155 | | |
| Specific Heat Capacity | J/(Kg•K) | | 460 | | | 59 | | | |
| Thermal Conductivity | W/(m•K) | | 50 | | | | | | |
| Density | Kg/dm ³ | | 7.85 | | | | | | |
| Specific Electric Resist. | Ohm•mm ² /m | | 0.12 | | | | | | |
| Electrical Conductivity | Siemens•m/mm ² | | 8.33 | | | | | | |
| °C | | | 20 | 100 | 200 | 300 | 400 | 500 | 600 |

The symbol ► indicates temperature between 20 °C and 100 °C, 20 °C and 200 °C ...

| Heat treatment | Temperature (+ ... °C) - min. values | | | | | | | | Data under fatigue |
|----------------|--------------------------------------|-----|-----|-----|-----|-----|-----|-----|---|
| | 20 | 200 | 300 | 350 | 400 | 450 | 500 | 600 | |
| +QT Ø ≤ 150 mm | | 284 | 235 | 206 | | | | | Yield stress R_{p0.2} N/mm ² EN 10269: 01 |
| +N | | | | | | 100 | 70 | | Creep rupture, 10.000 h N/mm ² ¹⁾ |
| +N | | | | | | 55 | 35 | | Creep rupture, 100.000 h N/mm ² ¹⁾ |
| +U | 591 | | | | | | | | Cyclic yield strength, σ_y' |
| +SR | 336 | | | | | | | | N/mm ² |
| +N | 370 | | | | | | | | low cycle number |
| +QT | 462 | | | | | | | | |
| +U | 0.23 | | | | | | | | Cyclic strength exponent, n' |
| +SR | 0.09 | | | | | | | | low cycle number |
| +N | 0.15 | | | | | | | | |
| +QT | 0.13 | | | | | | | | |
| +U | 2407 | | | | | | | | Cyclic strength coefficient, K' |
| +SR | 599 | | | | | | | | N/mm ² |
| +N | 952 | | | | | | | | low cycle number |
| +QT | 1078 | | | | | | | | |
| +U | 774 | | | | | | | | Fatigue strength coefficient, σ_f' |
| +SR | 519 | | | | | | | | N/mm ² |
| +N | 1267 | | | | | | | | low cycle number |
| +QT | 1405 | | | | | | | | |
| +U | -0.06 | | | | | | | | Fatigue strength exponent, b |
| +SR | -0.04 | | | | | | | | low cycle number |
| +N | -0.14 | | | | | | | | |
| +QT | -0.11 | | | | | | | | |
| +U | 0.11 | | | | | | | | Fatigue ductility coefficient, g_f' |
| +SR | 0.12 | | | | | | | | low cycle number |
| +N | 0.42 | | | | | | | | |
| +QT | 0.61 | | | | | | | | |
| +U | -0.37 | | | | | | | | Fatigue ductility exponent, c |
| +SR | -0.42 | | | | | | | | low cycle fatigue |
| +N | -0.53 | | | | | | | | |
| +QT | -0.55 | | | | | | | | |
| +N | 190 | | | | | | | | Fatigue limit, σ_L' |
| +QT | 265 | | | | | | | | N/mm ² high cycle fatigue |

¹⁾ Creep rupture strength

+U = natural +N = normalized +QT = quenched and tempered +SR = stress-relieved

K_v values obtained on hot-rolled 130 mm round; **LUCEFIN** experience

| | | | | | | | | | |
|-----------|--|--------------|--------------|--------------|--------------|--|--|--|--|
| | +QT induction for R 743 N/mm ² Rp 421 N/mm ² A% 26 C% 58 | | | | | | | | |
| J | 50 - 57 - 60 | 36 - 33 - 40 | 32 - 41 - 28 | 14 - 24 - 24 | 16 - 26 - 14 | | | | |
| °C | +20 | 0 | -20 | -40 | -60 | | | | |