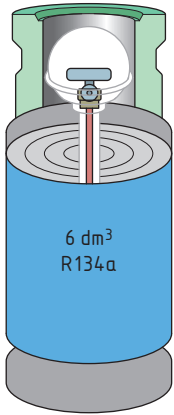


Dichte, Masse und Volumen

Abbildung



Formel / Formelumstellung

Dichte

$$\rho = \frac{m}{V} \quad m = V \cdot \rho \quad V = \frac{m}{\rho}$$

Spezifisches Volumen

$$v = \frac{1}{\rho} \quad v = \frac{V}{m} \quad m = \frac{V}{v} \quad V = v \cdot m$$

Formelzeichen / Einheiten

| | | |
|--------|----------------------|--------------------------------|
| ρ | Dichte | $\frac{\text{kg}}{\text{m}^3}$ |
| m | Masse | kg |
| V | Volumen | m^3, l |
| v | spezifisches Volumen | $\frac{\text{m}^3}{\text{kg}}$ |

Beispiel

$$V_R = 6 \text{ dm}^3$$

$$\rho = 1225,3 \frac{\text{kg}}{\text{m}^3}$$

$$m = ?$$

$$m = V \cdot \rho$$

$$m = 6 \text{ dm}^3 \cdot 1225,3 \frac{\text{kg}}{\text{m}^3} \cdot \frac{1 \text{ m}^3}{1000 \text{ dm}^3}$$

$$\underline{\underline{m = 7,35 \text{ kg}}}$$

Strömungslehre

| Formelzeichen / Einheiten | Formel / Formelumstellung | Abbildung |
|--|--------------------------------|-----------|
| \dot{V} Volumenstrom | $\frac{\text{m}^3}{\text{s}}$ | |
| A Strömungsquerschnitt | m^2 | |
| w Strömungsgeschwindigkeit | $\frac{\text{m}}{\text{s}}$ | |
| \dot{m} Massenstrom | $\frac{\text{kg}}{\text{s}}$ | |
| ρ Dichte | $\frac{\text{kg}}{\text{m}^3}$ | |
| d Rohrdurchmesser | mm | |
| Kontinuitätsgesetz Flüssigkeiten (inkompressibel) $\dot{V}_1 = \dot{V}_2$ $A_1 \cdot w_1 = A_2 \cdot w_2$ $\frac{A_1}{A_2} = \frac{w_2}{w_1} \quad w_2 = \frac{A_1}{A_2} \cdot w_1 \quad w_1 = \frac{A_2}{A_1} \cdot w_2$ | | |
| Gase (kompressibel) $\dot{m}_1 = \dot{m}_2$ $A_1 \cdot w_1 \cdot \rho_1 = A_2 \cdot w_2 \cdot \rho_2$ | | |
| Bei runden Rohrleitungen $d_1^2 \cdot w_1 = d_2^2 \cdot w_2$ $w_1 = \frac{d_2^2 \cdot w_2}{d_1^2}$ $d_1 = \sqrt{\frac{w_2}{w_1} \cdot d_2^2}$ $\frac{d_1^2}{d_2^2} = \frac{w_2}{w_1}$ $w_2 = \frac{d_1^2 \cdot w_1}{d_2^2}$ $d_2 = \sqrt{\frac{w_1}{w_2} \cdot d_1^2}$ | | |
| Indizes: 1 = Zustand großer Durchmesser 2 = Zustand kleiner Durchmesser | | |

Beispiel

$$w_1 = 3,19 \frac{\text{m}}{\text{s}}$$

$$w_2 = 4,17 \frac{\text{m}}{\text{s}}$$

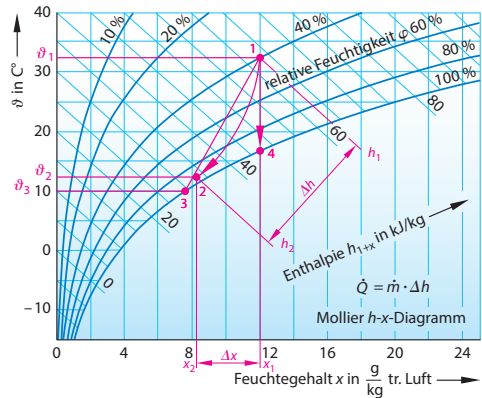
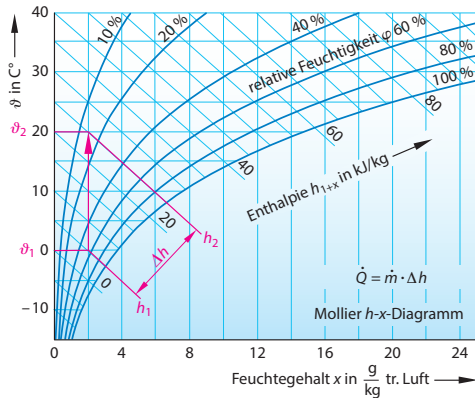
$$d_2 = 14 \text{ mm}$$

$$d_1 = ?$$

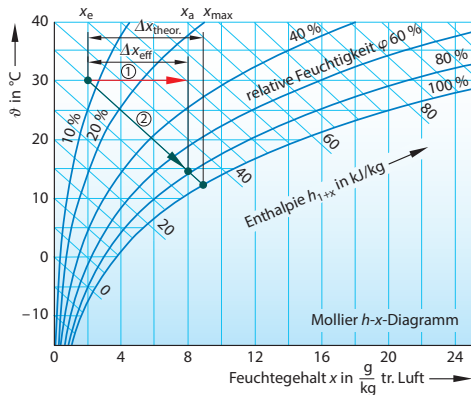
$$d_1 = \sqrt{\frac{w_2}{w_1} \cdot d_2^2}$$

$$d_1 = \sqrt{\frac{4,17 \frac{\text{m}}{\text{s}}}{3,19 \frac{\text{m}}{\text{s}}} \cdot (14 \text{ mm})^2} = \underline{\underline{16 \text{ mm}}}$$

Grundlagen

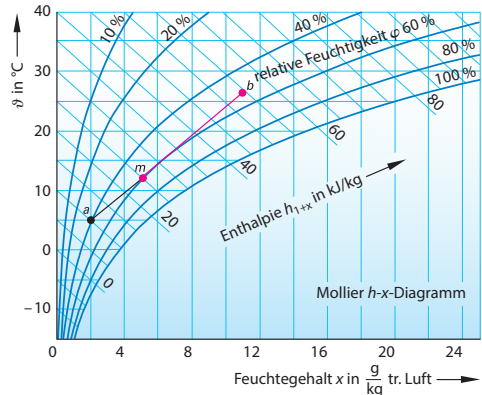


Erwärmung im h - x -Diagramm



- ① Dampfzufeuchtung, isotherm
 ② Umlauf-Sprühzufeuchtung, adiabatisch

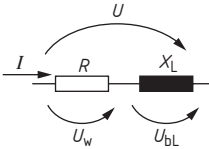
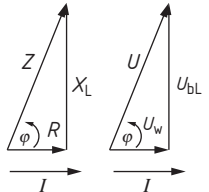
Kühlen und Entfeuchten im h - x -Diagramm



Befeuchtungsverlauf im h - x -Diagramm

Luftmischung im h - x -Diagramm

Wechselspannungsgeräte

| Abbildung | Formel / Formelumstellung | Formelzeichen / Einheiten |
|---|---|--|
| <p>Reihenschaltung aus Wirkwiderstand und Induktivität</p>   | $Z = \sqrt{R^2 + X_L^2}$ $R = \sqrt{Z^2 - X_L^2}$ $X_L = \sqrt{Z^2 - R^2}$ $R = Z \cdot \cos \varphi$ $Z = \frac{R}{\cos \varphi}$ $X_L = Z \cdot \sin \varphi$ $Z = \frac{R}{\sin \varphi}$ $U = \sqrt{U_W^2 + U_{bL}^2}$ $U_W = \sqrt{U^2 - U_{bL}^2}$ $U_{bL} = \sqrt{U^2 - U_W^2}$ $U = I \cdot Z$ $I = \frac{U}{Z}$ $Z = \frac{U}{I}$ $U_W = U \cdot \cos \varphi$ $U_{bL} = U \cdot \sin \varphi$ | <p>Z Scheinwiderstand Ω</p> <p>R Wirkwiderstand Ω</p> <p>X_L induktiver Blindwiderstand Ω</p> <p>φ Phasenverschiebungswinkel $^\circ$</p> <p>$\cos \varphi$ Wirkfaktor</p> <p>$\sin \varphi$ Blindfaktor</p> <p>U Gesamtspannung V</p> <p>U_W Wirkspannung V</p> <p>U_{bL} induktive Blindspannung V</p> <p>I Stromstärke A</p> |

Beispiel

$$R = 200 \Omega$$

$$L = 0,5 H$$

$$U = 230 V / 50 Hz$$

$$Z = ?$$

$$Z = \sqrt{R^2 + X_L^2} = \sqrt{(200 \Omega)^2 + (157,07 \Omega)^2} = \underline{\underline{254,30 \Omega}}$$

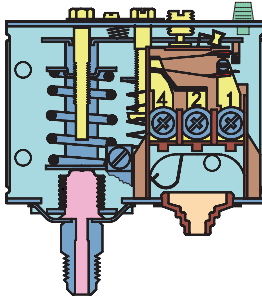
NR (vgl. S. 111):

$$X_L = 2 \cdot \pi \cdot f \cdot L = 2 \cdot \pi \cdot 50 Hz \cdot 0,5 H = \underline{\underline{157,07 \Omega}}$$

Druckschalter

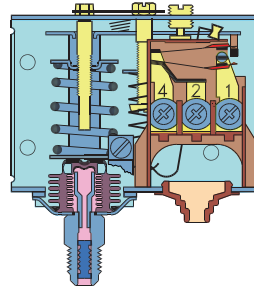
Niederdruckschalter

Danfoss KP1



Hochdruckschalter (Wächter)

Danfoss KP7W



Kontaktsysteme

Aus: Danfoss Tipps für den Monteur

| Niederdruck (LP) | Hochdruck (HP) | |
|---|--|--|
| <p>SPDT</p> <p>DANFOSS AG0-943.13</p> | <p>Hinweis:</p> <p>SPST → single pole – single throw SPDT → single pole – double throw</p> | <p>SPDT</p> <p>DANFOSS AG0-944.13</p> |
| Dualdruck (LP / HP) | Dualdruck (LP / HP) | Dualdruck (HP / HP) |
| <p>SPDT+LP signal</p> <p>Danfoss 60-581.15</p> | <p>SPDT+LP+HP signal</p> <p>DANFOSS AG0-993.14</p> | <p>SPST</p> <p>DANFOSS AG0-366.17</p> |

Dampftafel R290 Nassdampf (Daikin Ref 11 Berechnungsprogramm)

| ϑ | p | v' | v'' | h' | h'' | Δh | ϑ | p | v' | v'' | h' | h'' | Δh |
|-------------|------|---------------------|---------------------|--------|--------|------------|-------------|-------|---------------------|---------------------|--------|--------|------------|
| °C | bar | dm ³ /kg | dm ³ /kg | kJ/kg | kJ/kg | kJ/kg | °C | bar | dm ³ /kg | dm ³ /kg | kJ/kg | kJ/kg | kJ/kg |
| -30 | 1,68 | 566,7 | 3,875 | 127,48 | 540,39 | 412,92 | 8 | 6,01 | 517,5 | 13,06 | 220,69 | 583,17 | 362,48 |
| -29 | 1,74 | 565,5 | 4,019 | 129,76 | 541,56 | 411,8 | 9 | 6,19 | 516,1 | 13,44 | 223,3 | 584,23 | 360,93 |
| -28 | 1,81 | 564,3 | 4,168 | 132,05 | 542,73 | 410,68 | 10 | 6,37 | 514,7 | 13,82 | 225,92 | 585,29 | 359,38 |
| -27 | 1,89 | 563,1 | 4,321 | 134,35 | 543,89 | 409,54 | 11 | 6,55 | 513,3 | 14,2 | 228,54 | 586,35 | 357,81 |
| -26 | 1,96 | 561,9 | 4,479 | 136,66 | 545,06 | 408,4 | 12 | 6,73 | 511,8 | 14,6 | 231,16 | 587,4 | 356,23 |
| -25 | 2,03 | 560,7 | 4,64 | 138,98 | 546,22 | 407,24 | 13 | 6,92 | 510,4 | 15,01 | 233,8 | 588,44 | 354,64 |
| -24 | 2,11 | 559,4 | 4,806 | 141,31 | 547,38 | 406,07 | 14 | 7,12 | 508,9 | 15,42 | 236,44 | 589,48 | 353,04 |
| -23 | 2,19 | 558,2 | 4,977 | 143,65 | 548,53 | 404,89 | 15 | 7,32 | 507,5 | 15,85 | 239,08 | 590,52 | 351,43 |
| -22 | 2,27 | 557 | 5,152 | 145,99 | 549,69 | 403,7 | 16 | 7,52 | 506 | 16,28 | 241,73 | 591,54 | 349,81 |
| -21 | 2,36 | 555,7 | 5,332 | 148,35 | 550,84 | 402,49 | 17 | 7,72 | 504,5 | 16,73 | 244,39 | 592,57 | 348,18 |
| -20 | 2,44 | 554,5 | 5,517 | 150,72 | 552 | 401,28 | 18 | 7,93 | 503 | 17,18 | 247,05 | 593,59 | 346,54 |
| -19 | 2,53 | 553,3 | 5,707 | 153,1 | 553,15 | 400,05 | 19 | 8,15 | 501,5 | 17,64 | 249,72 | 594,6 | 344,88 |
| -18 | 2,63 | 552 | 5,902 | 155,49 | 554,29 | 398,81 | 20 | 8,37 | 500 | 18,12 | 252,39 | 595,61 | 343,22 |
| -17 | 2,72 | 550,7 | 6,102 | 157,88 | 555,44 | 397,55 | 21 | 8,59 | 498,5 | 18,6 | 255,07 | 596,61 | 341,54 |
| -16 | 2,82 | 549,5 | 6,307 | 160,29 | 556,58 | 396,29 | 22 | 8,81 | 497 | 19,1 | 257,75 | 597,6 | 339,85 |
| -15 | 2,92 | 548,2 | 6,517 | 162,71 | 557,72 | 395,01 | 23 | 9,05 | 495,4 | 19,6 | 260,44 | 598,59 | 338,15 |
| -14 | 3,02 | 547 | 6,733 | 165,14 | 558,86 | 393,73 | 24 | 9,28 | 493,9 | 20,12 | 263,14 | 599,57 | 336,44 |
| -13 | 3,12 | 545,7 | 6,954 | 167,57 | 560 | 392,43 | 25 | 9,52 | 492,3 | 20,65 | 265,84 | 600,55 | 334,71 |
| -12 | 3,23 | 544,4 | 7,181 | 170,02 | 561,13 | 391,11 | 26 | 9,77 | 490,7 | 21,19 | 268,55 | 601,51 | 332,97 |
| -11 | 3,34 | 543,1 | 7,413 | 172,47 | 562,26 | 389,79 | 27 | 10,01 | 489,2 | 21,75 | 271,26 | 602,48 | 331,22 |
| -10 | 3,45 | 541,8 | 7,651 | 174,94 | 563,39 | 388,45 | 28 | 10,27 | 487,6 | 22,31 | 273,98 | 603,43 | 329,45 |
| -9 | 3,57 | 540,5 | 7,895 | 177,41 | 564,52 | 387,11 | 29 | 10,53 | 486 | 22,89 | 276,71 | 604,37 | 327,67 |
| -8 | 3,69 | 539,2 | 8,145 | 179,89 | 565,64 | 385,75 | 30 | 10,79 | 484,3 | 23,48 | 279,44 | 605,31 | 325,87 |
| -7 | 3,81 | 537,9 | 8,402 | 182,38 | 566,76 | 384,38 | 31 | 11,06 | 482,7 | 24,08 | 282,18 | 606,24 | 324,06 |
| -6 | 3,93 | 536,6 | 8,664 | 184,88 | 567,88 | 383 | 32 | 11,33 | 481,1 | 24,7 | 284,93 | 607,16 | 322,24 |
| -5 | 4,06 | 535,3 | 8,933 | 187,39 | 568,99 | 381,6 | 33 | 11,61 | 479,4 | 25,33 | 287,68 | 608,07 | 320,39 |
| -4 | 4,19 | 534 | 9,208 | 189,91 | 570,1 | 380,2 | 34 | 11,89 | 477,7 | 25,98 | 290,44 | 608,98 | 318,53 |
| -3 | 4,32 | 532,6 | 9,49 | 192,43 | 571,21 | 378,78 | 35 | 12,18 | 476,1 | 26,64 | 293,22 | 609,87 | 316,66 |
| -2 | 4,46 | 531,3 | 9,779 | 194,96 | 572,32 | 377,35 | 36 | 12,47 | 474,4 | 27,32 | 296 | 610,76 | 314,76 |
| -1 | 4,6 | 529,9 | 10,07 | 197,5 | 573,42 | 375,92 | 37 | 12,77 | 472,6 | 28,01 | 298,79 | 611,63 | 312,85 |
| 0 | 4,74 | 528,6 | 10,38 | 200 | 574,52 | 374,52 | 38 | 13,07 | 470,9 | 28,71 | 301,58 | 612,5 | 310,91 |
| 1 | 4,89 | 527,2 | 10,69 | 202,61 | 575,61 | 373,01 | 39 | 13,38 | 469,2 | 29,44 | 304,39 | 613,35 | 308,96 |
| 2 | 5,04 | 525,9 | 11 | 205,17 | 576,7 | 371,53 | 40 | 13,69 | 467,4 | 30,18 | 307,21 | 614,19 | 306,98 |
| 3 | 5,19 | 524,5 | 11,33 | 207,74 | 577,79 | 370,05 | 41 | 14,01 | 465,6 | 30,93 | 310,04 | 615,03 | 304,98 |
| 4 | 5,35 | 523,1 | 11,66 | 210,32 | 578,88 | 368,56 | 42 | 14,34 | 463,9 | 31,71 | 312,89 | 615,85 | 302,96 |
| 5 | 5,51 | 521,7 | 12 | 212,9 | 579,95 | 367,05 | 43 | 14,67 | 462 | 32,5 | 315,74 | 616,65 | 300,91 |
| 6 | 5,68 | 520,3 | 12,35 | 215,49 | 581,03 | 365,54 | 44 | 15 | 460,2 | 33,31 | 318,61 | 617,45 | 298,84 |
| 7 | 5,84 | 518,9 | 12,7 | 218,09 | 582,1 | 364,02 | 45 | 15,34 | 458,4 | 34,14 | 321,49 | 618,23 | 296,74 |

Dampf tabel R290 überhitzt (Daikin Ref 11 Berechnungsprogramm)

| $\vartheta_s = -30,00\text{ °C}$ | | | | $\vartheta_s = -28,00\text{ °C}$ | | | | $\vartheta_s = -26,00\text{ °C}$ | | | |
|----------------------------------|---------------------|--------|-----------|----------------------------------|---------------------|--------|-----------|----------------------------------|---------------------|--------|-----------|
| $p_s = 1,677\text{ bar}$ | | | | $p_s = 1,813\text{ bar}$ | | | | $p_s = 1,958\text{ bar}$ | | | |
| ϑ | v | h | s | ϑ | v | h | s | ϑ | v | h | s |
| °C | dm ³ /kg | kJ/kg | kJ/(kg K) | °C | dm ³ /kg | kJ/kg | kJ/(kg K) | °C | dm ³ /kg | kJ/kg | kJ/(kg K) |
| -30 | 258,21 | 540,4 | 2,419 | -28 | 240,04 | 542,73 | 2,4147 | -26 | 223,32 | 545,06 | 2,4105 |
| -28 | 260,78 | 543,46 | 2,4316 | -26 | 242,43 | 545,82 | 2,4273 | -24 | 225,55 | 548,18 | 2,4231 |
| -26 | 263,34 | 546,53 | 2,444 | -24 | 244,81 | 548,92 | 2,4397 | -22 | 227,77 | 551,3 | 2,4356 |
| -24 | 265,88 | 549,62 | 2,4565 | -22 | 247,18 | 552,03 | 2,4522 | -20 | 229,99 | 554,44 | 2,448 |
| -22 | 268,42 | 552,71 | 2,4688 | -20 | 249,54 | 555,15 | 2,4645 | -18 | 232,19 | 557,58 | 2,4604 |
| -20 | 270,95 | 555,81 | 2,4811 | -18 | 251,9 | 558,28 | 2,4769 | -16 | 234,38 | 560,74 | 2,4727 |
| -18 | 273,47 | 558,93 | 2,4934 | -16 | 254,24 | 561,42 | 2,4891 | -14 | 236,57 | 563,91 | 2,485 |
| -16 | 275,98 | 562,05 | 2,5056 | -14 | 256,58 | 564,57 | 2,5013 | -12 | 238,74 | 567,08 | 2,4972 |
| -14 | 278,48 | 565,19 | 2,5177 | -12 | 258,91 | 567,73 | 2,5135 | -10 | 240,91 | 570,27 | 2,5094 |
| -12 | 280,98 | 568,34 | 2,5298 | -10 | 261,23 | 570,91 | 2,5256 | -8 | 243,08 | 573,47 | 2,5215 |
| -10 | 283,46 | 571,5 | 2,5419 | -8 | 263,54 | 574,09 | 2,5376 | -6 | 245,23 | 576,68 | 2,5335 |
| -8 | 285,94 | 574,67 | 2,5539 | -6 | 265,85 | 577,29 | 2,5497 | -4 | 247,38 | 579,9 | 2,5455 |
| -6 | 288,42 | 577,86 | 2,5659 | -4 | 268,15 | 580,5 | 2,5616 | -2 | 249,52 | 583,14 | 2,5575 |
| -4 | 290,88 | 581,05 | 2,5778 | -2 | 270,44 | 583,72 | 2,5736 | 0 | 251,65 | 586,39 | 2,5695 |
| -2 | 293,34 | 584,27 | 2,5897 | 0 | 272,73 | 586,96 | 2,5854 | 2 | 253,78 | 589,65 | 2,5813 |
| 0 | 295,8 | 587,49 | 2,6015 | 2 | 275,01 | 590,21 | 2,5973 | 4 | 255,91 | 592,92 | 2,5932 |
| 2 | 298,25 | 590,73 | 2,6133 | 4 | 277,28 | 593,47 | 2,6091 | 6 | 258,02 | 596,2 | 2,605 |
| 4 | 300,69 | 593,98 | 2,6251 | 6 | 279,55 | 596,74 | 2,6209 | 8 | 260,14 | 599,5 | 2,6168 |
| 6 | 303,13 | 597,24 | 2,6369 | 8 | 281,82 | 600,03 | 2,6326 | 10 | 262,24 | 602,82 | 2,6285 |
| 8 | 305,56 | 600,52 | 2,6486 | 10 | 284,08 | 603,33 | 2,6443 | 12 | 264,34 | 606,14 | 2,6402 |
| 10 | 307,99 | 603,81 | 2,6602 | 12 | 286,33 | 606,65 | 2,656 | 14 | 266,44 | 609,48 | 2,6519 |
| 12 | 310,41 | 607,12 | 2,6719 | 14 | 288,58 | 609,98 | 2,6676 | 16 | 268,53 | 612,84 | 2,6635 |
| 14 | 312,83 | 610,44 | 2,6835 | 16 | 290,83 | 613,32 | 2,6792 | 18 | 270,62 | 616,2 | 2,6751 |
| 16 | 315,24 | 613,78 | 2,695 | 18 | 293,07 | 616,68 | 2,6908 | 20 | 272,71 | 619,59 | 2,6867 |
| 18 | 317,65 | 617,13 | 2,7066 | 20 | 295,31 | 620,06 | 2,7024 | 22 | 274,79 | 622,98 | 2,6983 |