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Design of Engine Valves Formulas

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List of 44 Design of Engine Valves Formulas

Design of Engine Valves

Valve Disk

1) Bending Stress in Valve Disk

$$\text{fx } \sigma_{b_{\text{disk}}} = \left(\frac{d_p \cdot k_c}{t} \right)^2 \cdot p_{\text{max}}$$

[Open Calculator !\[\]\(de95854c7ee024cfadc48187bbb781b2_img.jpg\)](#)

$$\text{ex } 52.89256 \text{ N/mm}^2 = \left(\frac{40 \text{ mm} \cdot 0.5}{5.5 \text{ mm}} \right)^2 \cdot 4 \text{ MPa}$$

2) Diameter of Port given Thickness of Valve Disk

$$\text{fx } d_p = \frac{t}{k_c} \cdot \sqrt{\frac{\sigma_{b_{\text{disk}}}}{p_{\text{max}}}}$$

[Open Calculator !\[\]\(6a9b39b98eb945faa14c645ec99e4eaa_img.jpg\)](#)

$$\text{ex } 39.66106 \text{ mm} = \frac{5.5 \text{ mm}}{0.5} \cdot \sqrt{\frac{52 \text{ N/mm}^2}{4 \text{ MPa}}}$$

3) Maximum Thickness of Valve Disk at Edges

$$\text{fx } t_e = 0.85 \cdot t$$

[Open Calculator !\[\]\(f1c5da15572e3e09d343161be98f508d_img.jpg\)](#)

$$\text{ex } 4.675 \text{ mm} = 0.85 \cdot 5.5 \text{ mm}$$



4) Minimum Thickness of Valve Disk at Edges

$$fx \quad t_e = 0.75 \cdot t$$

[Open Calculator !\[\]\(cbe80b694ebd74fcfe136a095b608235_img.jpg\)](#)

$$ex \quad 4.125\text{mm} = 0.75 \cdot 5.5\text{mm}$$

5) Thickness of Valve Disk

$$fx \quad t = k_c \cdot d_p \cdot \sqrt{\frac{p_{\max}}{\sigma b_{\text{disk}}}}$$

[Open Calculator !\[\]\(3e2231b1ad3ca8da8658228c00dd08e0_img.jpg\)](#)

$$ex \quad 5.547002\text{mm} = 0.5 \cdot 40\text{mm} \cdot \sqrt{\frac{4\text{MPa}}{52\text{N/mm}^2}}$$

6) Thickness of Valve Disk given Projected Width of Valve Seat

$$fx \quad t = k_c \cdot \frac{w}{0.06} \cdot \sqrt{\frac{p_{\max}}{\sigma b_{\text{disk}}}}$$

[Open Calculator !\[\]\(0d5ec72f61334709c3fc9450209b754f_img.jpg\)](#)

$$ex \quad 6.933752\text{mm} = 0.5 \cdot \frac{3\text{mm}}{0.06} \cdot \sqrt{\frac{4\text{MPa}}{52\text{N/mm}^2}}$$

7) Thickness of Valve Disk Made of Cast Iron

$$fx \quad t = 0.54 \cdot d_p \cdot \sqrt{\frac{p_{\max}}{\sigma b_{\text{disk}}}}$$

[Open Calculator !\[\]\(b64b40baaee5acddc1eab8538ba84754_img.jpg\)](#)

$$ex \quad 5.990762\text{mm} = 0.54 \cdot 40\text{mm} \cdot \sqrt{\frac{4\text{MPa}}{52\text{N/mm}^2}}$$



8) Thickness of Valve Disk Made of Steel

[Open Calculator !\[\]\(dfbd6b3763a6d1d9afaa974f64e2e4b5_img.jpg\)](#)

$$\text{fx } t = 0.42 \cdot d_p \cdot \sqrt{\frac{P_{\max}}{\sigma b_{\text{disk}}}}$$

$$\text{ex } 4.659482\text{mm} = 0.42 \cdot 40\text{mm} \cdot \sqrt{\frac{4\text{MPa}}{52\text{N/mm}^2}}$$

Valve Head

9) Diameter of Port given Diameter of Valve Head and Projected Width of Valve Seat

[Open Calculator !\[\]\(05be7c7a8995decd503647c99211f7c2_img.jpg\)](#)

$$\text{fx } d_p = d_v - 2 \cdot w$$

$$\text{ex } 44\text{mm} = 50\text{mm} - 2 \cdot 3\text{mm}$$

10) Diameter of Port given Projected Width of Valve Seat

[Open Calculator !\[\]\(fe3aebe81acea8d45108cd2768939da7_img.jpg\)](#)

$$\text{fx } d_p = \frac{w}{0.06}$$

$$\text{ex } 50\text{mm} = \frac{3\text{mm}}{0.06}$$

11) Diameter of Valve Head given Diameter of Port and Projected Width of Valve Seat

[Open Calculator !\[\]\(899d8b7697d64725bf017d3296cfcf1b_img.jpg\)](#)

$$\text{fx } d_v = d_p + 2 \cdot w$$

$$\text{ex } 46\text{mm} = 40\text{mm} + 2 \cdot 3\text{mm}$$



12) Diameter of Valve Head given Load on Exhaust Valve and Back Pressure

$$\text{fx } d_v = \sqrt{\frac{4 \cdot P_g}{\pi \cdot P_{\text{back}}}}$$

[Open Calculator !\[\]\(e2376d476d06eb31946dc01a69a4403a_img.jpg\)](#)

$$\text{ex } 51.70883\text{mm} = \sqrt{\frac{4 \cdot 1680\text{N}}{\pi \cdot 0.8\text{MPa}}}$$

13) Diameter of Valve Head given Port Diameter

$$\text{fx } d_v = 1.12 \cdot d_p$$

[Open Calculator !\[\]\(0b5e7e25e8775f7e7e80906ada4f0021_img.jpg\)](#)

$$\text{ex } 44.8\text{mm} = 1.12 \cdot 40\text{mm}$$

14) Diameter of Valve Head given Projected Width of Valve Seat

$$\text{fx } d_v = 18.666 \cdot w$$

[Open Calculator !\[\]\(bd3b31712ad9bab5a241210fa6925cdd_img.jpg\)](#)

$$\text{ex } 55.998\text{mm} = 18.666 \cdot 3\text{mm}$$

15) Maximum Projected Width of Valve Seat given Port Diameter

$$\text{fx } w = 0.07 \cdot d_p$$

[Open Calculator !\[\]\(7bc43b319a082987e20f7bf78f4bab80_img.jpg\)](#)

$$\text{ex } 2.8\text{mm} = 0.07 \cdot 40\text{mm}$$

16) Minimum Projected Width of Valve Seat given Port Diameter

$$\text{fx } w = 0.05 \cdot d_p$$

[Open Calculator !\[\]\(4a7b4ce770af8456e11a71f9565c8c2b_img.jpg\)](#)

$$\text{ex } 2\text{mm} = 0.05 \cdot 40\text{mm}$$



17) Port Diameter given Diameter of Valve Head

$$fx \quad d_p = \frac{d_v}{1.12}$$

[Open Calculator !\[\]\(d3fb9f94af8b26d1c844efa9a98805b0_img.jpg\)](#)

$$ex \quad 44.64286mm = \frac{50mm}{1.12}$$

18) Projected Width of Valve Seat given Diameter of Port and Diameter of Valve Head

$$fx \quad w = \frac{d_v - d_p}{2}$$

[Open Calculator !\[\]\(e1d6102fe77919492c04879c8450f1f5_img.jpg\)](#)

$$ex \quad 5mm = \frac{50mm - 40mm}{2}$$

19) Projected Width of Valve Seat given Diameter of Valve Head

$$fx \quad w = \frac{d_v}{18.666}$$

[Open Calculator !\[\]\(ab4e2b3fc7e7887b7a72f548aa6f5e60_img.jpg\)](#)

$$ex \quad 2.678667mm = \frac{50mm}{18.666}$$

20) Projected Width of Valve Seat given Port Diameter

$$fx \quad w = 0.06 \cdot d_p$$

[Open Calculator !\[\]\(5abce1a84a655b073239ab33e1199487_img.jpg\)](#)

$$ex \quad 2.4mm = 0.06 \cdot 40mm$$



Valve Lift

21) Diameter of Port given Maximum Lift of Valve

$$\text{fx } d_p = 4 \cdot h_{\max} \cdot \cos(\alpha)$$

[Open Calculator !\[\]\(83f22ed94ec5517769dd76d702c6bfd8_img.jpg\)](#)

$$\text{ex } 31.1127\text{mm} = 4 \cdot 11\text{mm} \cdot \cos(45^\circ)$$

22) Force Required to Lift Engine Valve

$$\text{fx } P_2 = k \cdot h_{\max}$$

[Open Calculator !\[\]\(3cb60d42b10e53f9522bb0b392c1c4cd_img.jpg\)](#)

$$\text{ex } 102.3\text{N} = 9.3\text{N/mm} \cdot 11\text{mm}$$

23) Lift of Engine Valve

$$\text{fx } h_{\max} = \frac{P_2}{k}$$

[Open Calculator !\[\]\(0d7ca0919e6c47bbd874bfa0189fe22e_img.jpg\)](#)

$$\text{ex } 26.88172\text{mm} = \frac{250\text{N}}{9.3\text{N/mm}}$$

24) Maximum Lift of Valve for Flat Headed Valves

$$\text{fx } h_{\max} = \frac{d_p}{4}$$

[Open Calculator !\[\]\(683dba75afe26e28cd4de5730b776760_img.jpg\)](#)

$$\text{ex } 10\text{mm} = \frac{40\text{mm}}{4}$$



25) Maximum Lift of Valve given Diameter of Port and Valve Seat Angle

$$\text{fx } h_{\max} = \frac{d_p}{4 \cdot \cos(\alpha)}$$

[Open Calculator !\[\]\(6605b201d6f14d9b3bcb8ab5f274d107_img.jpg\)](#)

$$\text{ex } 14.14214\text{mm} = \frac{40\text{mm}}{4 \cdot \cos(45^\circ)}$$

26) Valve Seat Angle given Maximum Lift of Valve

$$\text{fx } \alpha = \arccos\left(\frac{d_p}{4 \cdot h_{\max}}\right)$$

[Open Calculator !\[\]\(e8fb589d58dad1692debababa5e928b6_img.jpg\)](#)

$$\text{ex } 24.61998^\circ = \arccos\left(\frac{40\text{mm}}{4 \cdot 11\text{mm}}\right)$$

Valve Port

27) Acceleration of Exhaust Valve

$$\text{fx } a_v = \frac{P a_{\text{valve}}}{m}$$

[Open Calculator !\[\]\(e9474ce1d70442456f8fe9c393ea149c_img.jpg\)](#)

$$\text{ex } 255.5556\text{m/s}^2 = \frac{115\text{N}}{0.45\text{kg}}$$



28) Area of IC Engine Port given Cross-Section Area of Piston

$$\text{fx } a_p = \frac{a \cdot s_p}{v_p}$$

[Open Calculator !\[\]\(71ceb62b681518c82e95d615e7265d66_img.jpg\)](#)

$$\text{ex } 1318.5\text{mm}^2 = \frac{5860\text{mm}^2 \cdot 4.5\text{m/s}}{20\text{m/s}}$$

29) Cross-Section Area of IC Engine Piston given Area of Port

$$\text{fx } a = \frac{a_p \cdot v_p}{s_p}$$

[Open Calculator !\[\]\(fc3a57079704ef1b99671c8cafae23be_img.jpg\)](#)

$$\text{ex } 5511.111\text{mm}^2 = \frac{1240\text{mm}^2 \cdot 20\text{m/s}}{4.5\text{m/s}}$$

30) Diameter of IC Engine Port

$$\text{fx } d_p = \sqrt{\frac{4 \cdot a \cdot s_p}{v_p \cdot \pi}}$$

[Open Calculator !\[\]\(d5831b2ac75eb48b4c49d27e61d24c03_img.jpg\)](#)

$$\text{ex } 40.97275\text{mm} = \sqrt{\frac{4 \cdot 5860\text{mm}^2 \cdot 4.5\text{m/s}}{20\text{m/s} \cdot \pi}}$$



31) Diameter of IC Engine Port given Area of Port

$$\text{fx } d_p = \sqrt{\frac{4 \cdot a_p}{\pi}}$$

[Open Calculator !\[\]\(8b57f0e15e7dda24cf9977561475f640_img.jpg\)](#)

$$\text{ex } 39.73433\text{mm} = \sqrt{\frac{4 \cdot 1240\text{mm}^2}{\pi}}$$

32) Engine Speed given Mean Velocity of Piston and Stroke Length

$$\text{fx } N = 60 \cdot \frac{s_p}{2 \cdot l_s}$$

[Open Calculator !\[\]\(ceb7cef9f9d693d102dfe501130037c6_img.jpg\)](#)

$$\text{ex } 490.9091 = 60 \cdot \frac{4.5\text{m/s}}{2 \cdot 275\text{mm}}$$

33) Mean Velocity of Gas through IC Engine Port given Engine Speed, Stroke, Area of Piston and Port

$$\text{fx } v_p = \frac{a \cdot \frac{2 \cdot N \cdot l_s}{60}}{a_p}$$

[Open Calculator !\[\]\(5a09a9dfd2f1e923eccb8c24714edf51_img.jpg\)](#)

$$\text{ex } 21.65995\text{m/s} = \frac{5860\text{mm}^2 \cdot \frac{2 \cdot 500 \cdot 275\text{mm}}{60}}{1240\text{mm}^2}$$



34) Mean Velocity of Gas through IC Engine Port given Velocity of Piston

$$fx \quad v_p = \frac{a \cdot s_p}{a_p}$$

Open Calculator

$$ex \quad 21.26613m/s = \frac{5860mm^2 \cdot 4.5m/s}{1240mm^2}$$

35) Mean Velocity of IC Engine Piston given Engine Speed and Stroke**Length**

$$fx \quad s_p = \frac{2 \cdot N \cdot l_s}{60}$$

Open Calculator

$$ex \quad 4.583333m/s = \frac{2 \cdot 500 \cdot 275mm}{60}$$

36) Mean Velocity of IC Engine Piston given Velocity of Gas through Port

$$fx \quad s_p = \frac{a_p \cdot v_p}{a}$$

Open Calculator

$$ex \quad 4.232082m/s = \frac{1240mm^2 \cdot 20m/s}{5860mm^2}$$



37) Stroke Length of Piston given Mean Velocity of Piston and Engine Speed

$$\text{fx } l_s = \frac{60 \cdot s_p}{2 \cdot N}$$

[Open Calculator !\[\]\(65669ef2a9341eca7c5ba6092e766555_img.jpg\)](#)

$$\text{ex } 270\text{mm} = \frac{60 \cdot 4.5\text{m/s}}{2 \cdot 500}$$

Valve Stem

38) Diameter of Port given Diameter of Valve Stem

$$\text{fx } d_p = \frac{d_s}{1.5 \cdot \left(1 - \frac{\sigma_t \cdot t^2}{1.4 \cdot P_{sp}}\right)}$$

[Open Calculator !\[\]\(65e8f8322c024ac6fcf86b65a793ebdd_img.jpg\)](#)

$$\text{ex } 40.73903\text{mm} = \frac{15\text{mm}}{1.5 \cdot \left(1 - \frac{2.2\text{N/mm}^2 \cdot (5.5\text{mm})^2}{1.4 \cdot 63\text{N}}\right)}$$

39) Diameter of Valve Stem

$$\text{fx } d_s = 1.5 \cdot d_p \cdot \left(1 - \frac{\sigma_t \cdot t^2}{1.4 \cdot P_{sp}}\right)$$

[Open Calculator !\[\]\(0df0bdc1e09cbc2587d9dd4511cb0c27_img.jpg\)](#)

$$\text{ex } 14.72789\text{mm} = 1.5 \cdot 40\text{mm} \cdot \left(1 - \frac{2.2\text{N/mm}^2 \cdot (5.5\text{mm})^2}{1.4 \cdot 63\text{N}}\right)$$



40) Maximum Diameter of Valve Stem 

$$\text{fx } d_s = \frac{d_p}{8} + 11$$

[Open Calculator !\[\]\(b3131996c2d47980618867ba93d92313_img.jpg\)](#)

$$\text{ex } 16\text{mm} = \frac{40\text{mm}}{8} + 11$$

41) Minimum Diameter of Valve Stem 

$$\text{fx } d_s = \frac{d_p}{8} + 6.35$$

[Open Calculator !\[\]\(99af31d6d7b9b738106c66bf7ffde536_img.jpg\)](#)

$$\text{ex } 11.35\text{mm} = \frac{40\text{mm}}{8} + 6.35$$

42) Spring Force on Valve when Seated 

$$\text{fx } P_{sp} = \frac{\frac{\sigma_t \cdot t^2}{1 - \frac{2 \cdot d_s}{3 \cdot d_p}}}{1.4}$$

[Open Calculator !\[\]\(51c8b64a0f70f0b96d4cbd0a65299579_img.jpg\)](#)

$$\text{ex } 63.38095\text{N} = \frac{\frac{2.2\text{N/mm}^2 \cdot (5.5\text{mm})^2}{1 - \frac{2 \cdot 15\text{mm}}{3 \cdot 40\text{mm}}}}{1.4}$$



43) Tensile Stress in Valve Stem due to Spring Force on Valve

$$fx \quad \sigma_t = 1.4 \cdot \frac{P_{sp}}{t^2} \cdot \left(1 - \frac{2 \cdot d_s}{3 \cdot d_p} \right)$$

[Open Calculator !\[\]\(2020723f97c3fe13d8ecf52b30807736_img.jpg\)](#)

$$ex \quad 2.186777N/mm^2 = 1.4 \cdot \frac{63N}{(5.5mm)^2} \cdot \left(1 - \frac{2 \cdot 15mm}{3 \cdot 40mm} \right)$$

44) Thickness of Valve Disk given Force of Spring on Valve

$$fx \quad t = \sqrt{\frac{1.4 \cdot P_{sp} \cdot \left(1 - \frac{2 \cdot d_s}{3 \cdot d_p} \right)}{\sigma_t}}$$

[Open Calculator !\[\]\(2becda4813f27b5edb43f5299d7596ac_img.jpg\)](#)

$$ex \quad 5.483446mm = \sqrt{\frac{1.4 \cdot 63N \cdot \left(1 - \frac{2 \cdot 15mm}{3 \cdot 40mm} \right)}{2.2N/mm^2}}$$



Variables Used










- **a** Cross Section Area of Piston (Square Millimeter)
- **a_p** Area of Port (Square Millimeter)
- **a_v** Acceleration of Valve (Meter per Square Second)
- **d_p** Diameter of Port (Millimeter)
- **d_s** Diameter of Valve Stem (Millimeter)
- **d_v** Diameter of Valve Head (Millimeter)
- **h_{max}** Lift of Valve (Millimeter)
- **k** Stiffness of Valve Spring (Newton per Millimeter)
- **k_c** Material Constant
- **l_s** Stroke Length (Millimeter)
- **m** Mass of Valve (Kilogram)
- **N** Engine Speed in rpm
- **P₂** Force to Lift Engine Valve (Newton)
- **P_{back}** Back Pressure on Engine Valve (Megapascal)
- **P_g** Gas Load on Exhaust Valve (Newton)
- **p_{max}** Maximum Gas Pressure inside Cylinder (Megapascal)
- **P_{sp}** Spring Force on Seated Valve (Newton)
- **Pa_{valve}** Inertia Force on Valve (Newton)
- **s_p** Mean Piston Speed (Meter per Second)
- **t** Thickness of Valve Disk (Millimeter)
- **t_e** Thickness of Valve Disk at Edges (Millimeter)




- v_p Velocity of Gas through Port (Meter per Second)
- w Projected Width of Valve Seat (Millimeter)
- α Valve Seat Angle (Degree)
- σ_t Tensile Stress in Valve Stem (Newton per Square Millimeter)
- $\sigma_{b_{disk}}$ Bending Stress in Valve Disk (Newton per Square Millimeter)



Constants, Functions, Measurements used






- **Constant:** **pi**, 3.14159265358979323846264338327950288
Archimedes' constant
- **Function:** **arccos**, arccos(Number)
Inverse trigonometric cosine function
- **Function:** **cos**, cos(Angle)
Trigonometric cosine function
- **Function:** **sqrt**, sqrt(Number)
Square root function
- **Measurement:** **Length** in Millimeter (mm)
Length Unit Conversion 
- **Measurement:** **Weight** in Kilogram (kg)
Weight Unit Conversion 
- **Measurement:** **Area** in Square Millimeter (mm²)
Area Unit Conversion 
- **Measurement:** **Pressure** in Megapascal (MPa)
Pressure Unit Conversion 
- **Measurement:** **Speed** in Meter per Second (m/s)
Speed Unit Conversion 
- **Measurement:** **Acceleration** in Meter per Square Second (m/s²)
Acceleration Unit Conversion 
- **Measurement:** **Force** in Newton (N)
Force Unit Conversion 
- **Measurement:** **Angle** in Degree (°)
Angle Unit Conversion 
- **Measurement:** **Stiffness Constant** in Newton per Millimeter (N/mm)
Stiffness Constant Unit Conversion 



- **Measurement: Stress** in Newton per Square Millimeter (N/mm²)
Stress Unit Conversion 



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