KEYS AND KEYWAYS

Keys are used to transmit torque from a rotating machine element to the shaft.
**SQUARE & RECTANGULAR KEYS**

Standard contains tables of recommended key sizes versus shaft diameter.

- The hub is slightly larger than the shaft and key to allow it to slide over the shaft during assembly.
- The set screw is used to take up the slack.
- The resulting friction is used to provide resistance to axial motion. Thread adhesive may be required to ensure that vibration doesn’t cause the set screw to loosen.
TAPERED KEYS

Designed to be inserted from the end of the shaft after the hub is in position. The taper will impart a compressive contact pressure between the hub and the shaft. Friction will help transmit torque and provide resistance to axial motion of the hub relative to the shaft. Tapered keys do not require set screws. Access to both ends of tapered keys are required so that the key can be inserted and driven out when the key is being removed.
OTHER TYPES OF KEYS

Gib Head Keys

Woodruff Keys
A key has two failure mechanisms:
- 1. it can be sheared off, and
- 2. it can be crushed due to the compressive bearing forces.
SHEAR STRESS ANALYSIS

Square Rectangular Parallel Keys

\[ F = \frac{T}{D/2} \]

\[ A_s = WL \]

\[ \tau_{sve} = \frac{F}{A_s} = \frac{T}{(D/2)(WL)} \]

\[ \tau_{sve} = \frac{2T}{DWL} \]
REQUIRED KEY LENGTH IN SHEAR

- The required key length can be obtained using either the maximum shear stress theory or by setting the average stress equal to the allowable shear stress.

\[
S_{ys} = 0.5S_{yt}
\]

\[
\tau_{ave} = \frac{2T}{DLW} = \frac{0.5S_{yt}}{N_{fs}}
\]

\[
L_s = \frac{4TN_{fs}}{S_{yt}DW}
\]
**BEARING STRESS**

\[
\sigma_b = \frac{F}{A_b} \\
\sigma_{b,all} = \frac{K S_{yc}}{N_{fs}} \\
L_b = \frac{4TN_{fs}}{K S_{yc} DH}
\]

\[
F = \frac{T}{D/2} \\
A_b = \frac{HL}{2}
\]

**Triaxial Stress Factor**

\[1.0 \leq K \leq 1.5\]
SHEAR AND BEARING LENGTH

Minimum required Length to prevent shear failure:

\[ L_s = \frac{4TN_{fs}}{S_ytDW} \]

Minimum required Length to prevent bearing failure:

\[ L_b = \frac{4TN_{fs}}{KS_ycDH} \]

- If \( K = 1 \) in the \( L_b \) equation, these equations give the same result for a square key. (\( H = W \))
- In general \( K \) will be greater than 1.0 and more shear failures will be observed in the field.
- Keys are generally designed to fail before overloads can cause damage to the shaft or attached component.
STRESS CONCENTRATION FACTORS FOR KEYWAYS

- Cutting Keyways create stress concentrations in shafts.
- There are different stress concentration factors for bending and torsional loads.
- For flat end mills, it is recommended to use $K_t=2.14$ for bending and $K_{ts}=2.62$ for torsion.
- These may be reduced by using key seats made with bull end mills.
- The stress concentration factor for a sled runner key seat is significantly lower than for a profile key seat.
- A circular key and keyway will have lower stress concentration factors any other key geometry.