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The Gates Rubber Company
Denver, Colorado USA

Gear Unit Belt Drive Design Considerations
PA NOTE

When a belt drive is connected to the output shaft of a gear motor or reducer, the overhung load becomes a design consideration. Most gear unit manufacturers will publish or make available the maximum allowable overhung load for their units. This value should not be confused with the calculated belt pull, or shaft load, for the belt drive.

Speed reducers or gearboxes are a common component on many pieces of mechanical equipment, and more specifically, most conveyor systems. Light package conveyor applications are numerous at freight handling facilities (UPS, Airborne, etc.). Roller chain is commonly used as the mechanical means of power transmission from the reducer to a driveN shaft. Because of its high load capacity, corresponding compact drive size and low maintenance advantages, Poly Chain® GT® is a natural selection to replace roller chain on these applications. When converting these roller chain drives to belt drives, it is important that the overhung load is considered.

Overhung load is a force applied at right angles to the reducer shaft, beyond its outermost bearing. The applied force results from the chain or belt drive used to transmit power. Both the reducer's bearings and shaft must be capable of carrying the overhung load. If the overhung load is too large, premature bearing failure and shaft bending or breakage may result. The overhung load is dependent upon three factors: load connection factor ($\mathbf{K_{LCF}}$), gear unit service factor ($\mathbf{K_{SF}}$) and load location factor ($\mathbf{K_{LLF}}$).

Overhung load connection factors, called $\mathbf{K_{LCF}}$ factors by AGMA (American Gear Manufacturers Association), are used to modify the overhung load capacity of a speed reducer. The $\mathbf{K_{LCF}}$ factor is used to modify the calculated overhung load to compensate for varying types of drives.

The $\mathbf{K_{LCF}}$ factor (overhung load connection factor) will vary depending on the type of drive connected to the shaft. For example, a flat belt drive operates at relatively high tensions to prevent slippage. A roller chain drive operates with only the drive side of the chain in tension, with the other side slack. The $\mathbf{K_{LCF}}$ factor for flat belt is 2.5., compared to the 1.0 factor for chain. The flat belt drive will result in a much higher overhung load than the chain drive.

The proposed overhung load ($\mathbf{K_{LCF}}$) connection factors are as shown below. They have been accepted and published by AGMA.

Drive Type	K_{LCF}	Operating Tension Ratios (T_T/T_S)
Chain	1.0	—
Gear	1.25	—
Synch. Belt	1.3	8:1
V-Belt	1.5	5:1
V-Ribbed Belt	1.7	4:1
Flat Belt	2.5	2.5:1

The operating tension ratios are shown for reference purposes. The lower the tension ratio, the higher the overall operating tension.

The overhung load calculation is also dependent on a gear unit service factor (**K_{SF}**) which is independent from the belt service factor used when designing a belt drive. The gear unit service factor can vary from 1.0 to 2.0. The higher the service factor, the harsher the duty cycle for the gear unit. Gear unit manufacturers service factor tables should be consulted to determine an exact service factor.

One more factor must be obtained from the gear unit manufacturer - the load location factor (**K_{LLF}**). It is used by the designer to properly locate the overhung load with respect to the gear unit's bearings. The overhung load is assumed to be located at the center of the belt drive's width.

To calculate overhung load the following equation should be used:

$$OHL = \frac{(126{,}000)(HP)(K_{LCF})(K_{SF})(K_{LLF})}{(PD)(RPM)}$$

Where
- OHL = Overhung load (L.b.).
- HP = Actual horsepower being transmitted at the gear unit shaft with no service factor._
- K_{LCF} = Overhung load connection factor (1.3 for all synchronous belts).
- K_{SF} = Service factor for the gear unit (available from the manufacturer).
- K_{LLF} = Load location factor for the gear unit (available from the manufacturer).
- PD = Pitch diameter of the gear unit output shaft sprocket.
- RPM = RPM of the gear unit output.

Once the overhung load has been calculated, the reducer manufacturer should be consulted to determine the allowable overhung load. It is good design practice to locate the overhung load as close as possible to the reducer. It is important to check the available shaft length of the speed reducer to make sure that the selected belt drive is compatible. The amount of shaft length necessary for a specific driveR sprocket can be determined by consulting the dimensional information in the appropriate drive design catalog.

If the calculated overhung loads are larger than those recommended by the gear unit manufacturer, there are three methods to reduce overhung load:

1) Increase the diameter of the outboard sprocket or sheave.
2) Locate the overhung load closer to the reducer.
3) Use a belt type with a smaller K_{LCF} factor, (and, therefore, less total operating tension).

Remember that the gear motor/reducer manufacturer should always be contacted to determine the K_{SF}, K_{LFF} and allowable overhung loads.