Construction, Working and Installation of Freewheels (Backstops/Holdbacks)

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The information contained in this article represents a significant collection of technical information about construction, working and installation of freewheels. Freewheels are widely used as backstops/holdbacks on inclined conveyors. This information will help to achieve increased reliability at a decreased cost. Assemblage of this information will provide a single point of reference that might otherwise be time consuming to obtain. Most of information given in this article is mainly derived from literature on the subject from sources as per the reference list given at the end of this article. For more information, please refer them. All information contained in this article has been assembled with great care. However, the information is given for guidance purposes only. The ultimate responsibility for its use and any subsequent liability rests with the end user. Please view the disclaimer uploaded on http://www.practicalmaintenance.net.

(Edition: October 2018)

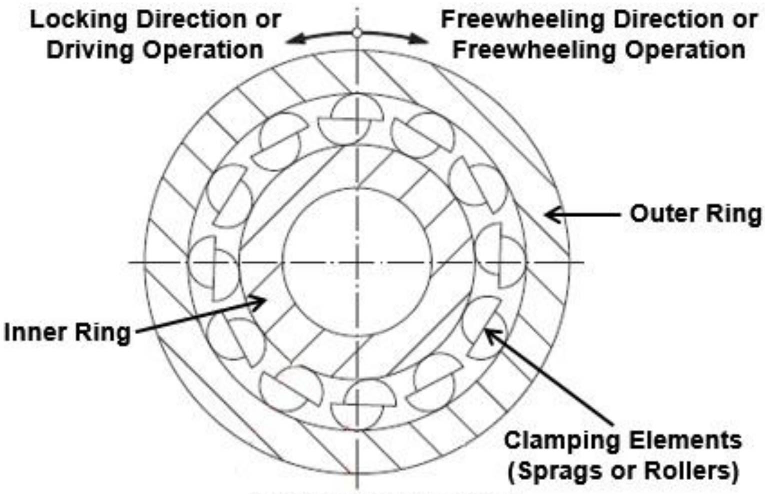
Construction and Working of Freewheels

Freewheels are “overrunning” clutches, i.e., they will drive in one direction but overrun (freewheel) in the other direction. They are used as backstops, overrunning clutches and indexing freewheels. Freewheels are widely used as backstops. A backstop when mounted on an inclined conveyor head shaft is commonly called holdback. Information about construction, working and installation of freewheels is given in this article.

Working of Freewheels

Freewheels are machine elements with following characteristics:

- In one direction of rotation there is no contact between the inner and outer ring; the freewheel is in freewheeling operation.
- In the other direction of rotation there is contact between the inner and outer ring; in this direction it is possible to stop rotation or transmit high torque.



Working of Freewheel

As shown in above schematic figure, freewheels consist of an inner ring and an outer ring between which clamping elements are arranged. Clamping elements can be sprags or rollers.

The outer ring of the freewheel shown in above figure can freewheel clockwise while the inner ring is stationary. If, however, the outer ring is turned in the opposite (anticlockwise) direction, there is contact between the inner and outer ring and the inner ring is driven (driving operation). In this direction (anticlockwise direction) of rotation, high torque can be transmitted.

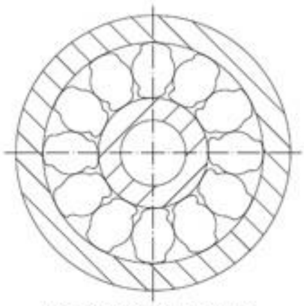
It may be noted that the outer ring can be turned freely clockwise (freewheeling operation), when the inner ring is turning clockwise at speed slower than the outer ring.

Freewheel Designs

Freewheel are available in two basic designs: sprag freewheels and roller freewheels.

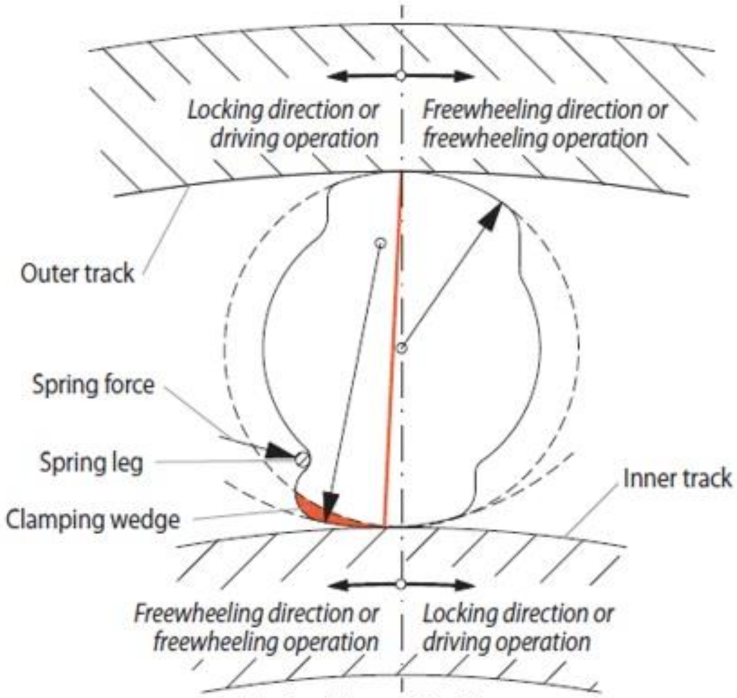
Sprag freewheels are most suitable as backstops, and mostly the contact-free versions. Roller freewheels are mainly used as overrunning and indexing clutches.

Sprag Freewheel



Sprag Freewheel

As shown in above figure, a sprag freewheel has outer and inner rings with cylindrical tracks. The individually spring loaded sprags are arranged in between the rings. The sprags, fitted in a cage, feature an active profile that ensures engagement or disengagement according to the relative motion of the races.



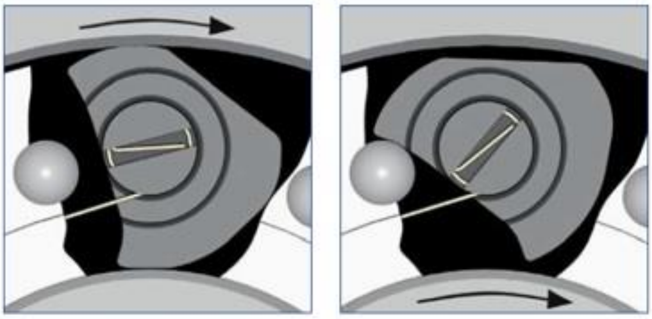
Typical Sprag Profile

As shown in above figure, due to the active profile (clamping wedge) on the sprag, the outer ring can be turned freely clockwise (freewheeling operation), if the inner ring is at a standstill, the inner ring is turned counterclockwise or is turned clockwise slower than the outer ring.

If the outer ring with a stationary inner ring is turned in the opposite direction, the clamping becomes effective. The sprags clamp without slipping between the tracks. In this direction of rotation high torque can be transmitted (driving operation).

The sprag profile illustrated in above figure also enables freewheeling operation while the inner ring is turned counterclockwise and driving operation when turned clockwise.

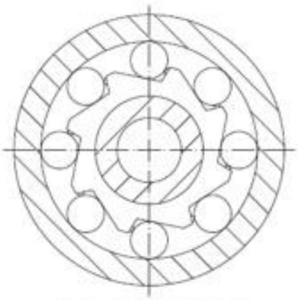
It is possible to adapt the design of sprags and cage to get significantly different characteristics from one model to another. For example, models which have permanent contact or are contact free running during overrunning, are available.



Contact Free Running During Overrunning

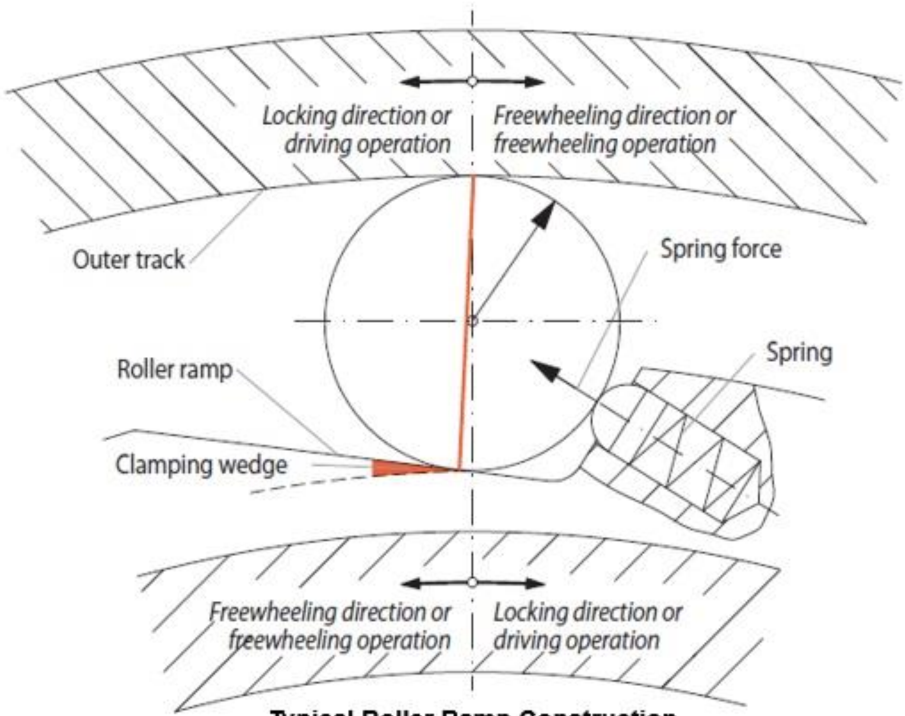
As shown in above figure, if sprag configuration is such that its centre of gravity is offset to its rotation axis, centrifugal force creates a lift off moment against an engaging spring resulting in contact free running during overrunning.

Roller Freewheel



Roller Freewheel

As shown in above figure, in roller freewheels either the inner or the outer ring has roller ramps. The other ring has a cylindrical track. The individually spring loaded rollers are arranged in between the rings.



Typical Roller Ramp Construction

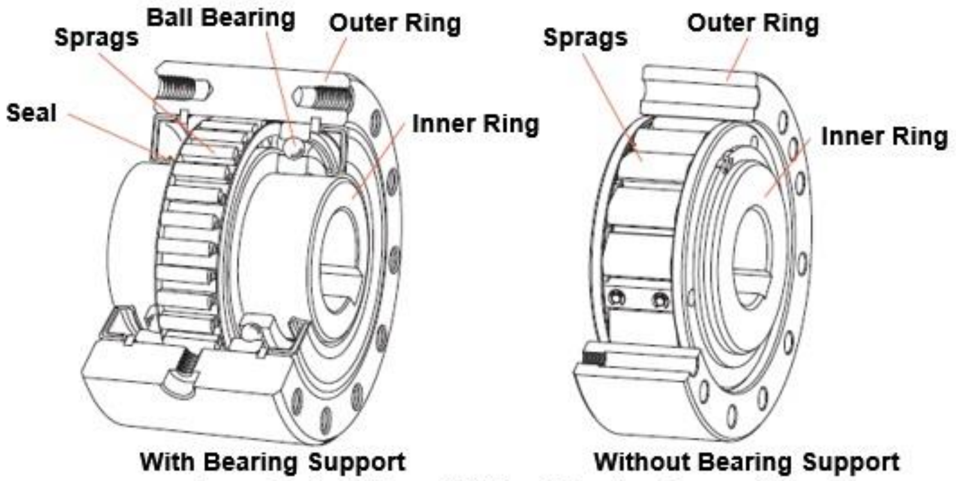
With the version illustrated in above figure, the outer ring can be turned freely clockwise (freewheeling operation), if the inner ring is at a standstill, is turned counterclockwise or is turned clockwise slower than the outer ring.

If the outer ring with a stationary inner ring is turned in the opposite direction, the clamping becomes effective. The rollers clamp without slipping between the tracks. In this direction of rotation high torque can be transmitted (driving operation).

The version illustrated in above figure also enables a freewheeling operation while the inner ring is turned counterclockwise and driving operation when turning clockwise.

Functional Requirement

For a freewheel to function, the concentric alignment of the inner and outer ring is required. For this, many times freewheels are supplied with bearing support. In the case of freewheels supplied without bearing support, concentric alignment device (like bearing) must be provided by the customer. The following figure shows freewheels with and without bearing support.



Freewheels With and Without Bearing Support

Uses of Freewheels

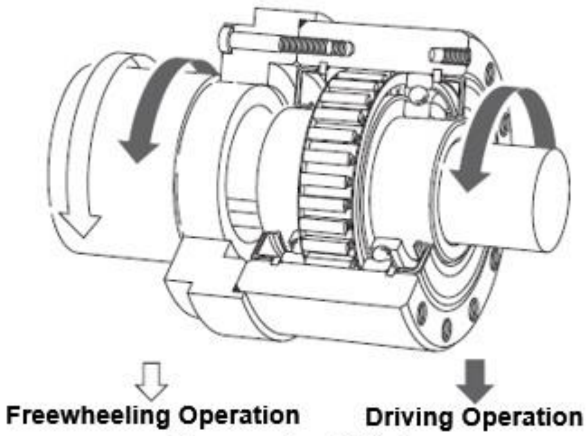
In selection of the correct freewheel design, overrunning clutch speed is a major determining factor in selecting the design best suited for each use/application. Roller freewheels are used for applications with low-to-medium overrunning speeds and for indexing. Sprag freewheels are the choice for applications with high overrunning speeds and for backstopping. The selection of the correct model (example: standard type, type with sprag lift, complete freewheels, cage freewheels, etc.) depends on several criteria. For information on various models and various criteria, please see information published /uploaded by the manufacturers or consult them.

Freewheels are used as:

- Overrunning clutches
- Indexing clutches
- Backstops/Holdbacks

Freewheels can fulfill above functions completely automatically in the most diverse machines.

Overrunning Clutches

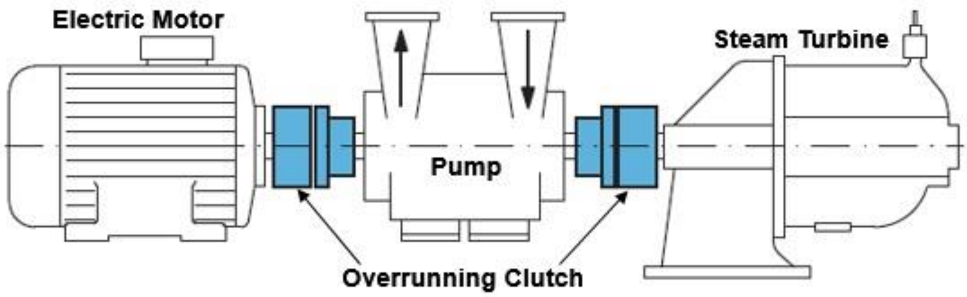


Overrunning Clutch

The overrunning clutch is a freewheel which engages machines or machine parts and automatically interrupts their contact as soon as the driven part of the overrunning clutch is turned faster than the driving part.

In overrunning clutches the engagement takes place in the driving operation (torque transmission), while in freewheeling operation the torque transmission between the inner and outer ring is interrupted. In driving operation, the speeds of the inner and outer ring are equal, while in freewheeling operation they are different. It may be noted that in an overrunning application, neither race is permanently grounded.

Above figure shows an overrunning clutch where, in driving operation the power/torque is transferred from the inner ring to the outer ring and in freewheeling operation the outer ring overruns the inner ring at a higher speed.



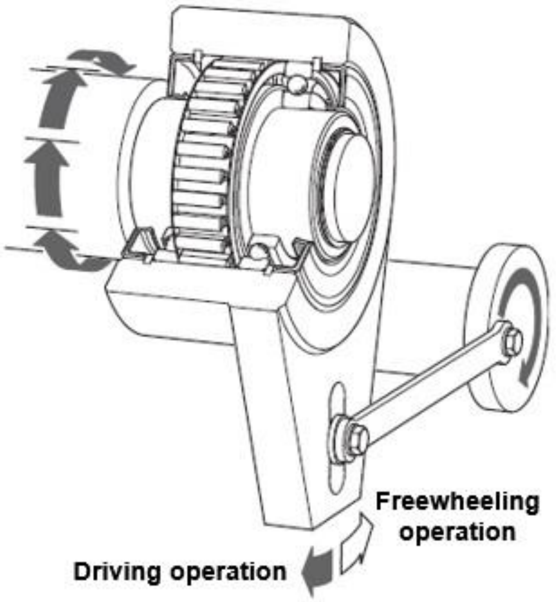
Pump Driven by Steam Turbine and Standby Electric Motor

Overrunning clutches are typically used by standby and compound drives because in a multiple drive system, the overrunning clutch disengages the inactive or lower speed drive. For example, as shown in above figure, a steam turbine and a standby electric motor may be connected to a single driven shaft of a pump through overrunning clutches. The shaft can then be driven by either the turbine or the motor or both with no further modification of the installation. The turbine drive clutch automatically engages when the turbine starts to drive, but automatically overruns when the load is transferred to the electric motor.

Indexing Clutches

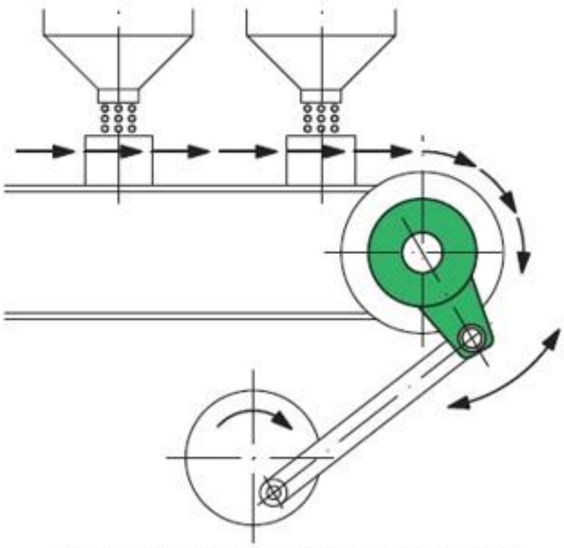
An indexing clutch is a freewheel which transmits/converts a reciprocating (back and forth) motion into a stepped/discontinuous rotational movement (indexed feed). In this type of use/application, reciprocating motion applied to the driving race is transformed into intermittent motion in only one direction at the driven race.

It may be noted that the overall accuracy of the indexing installation does not depend on the clutch but upon the fits and clearances within the entire train of the indexing mechanism.



Indexing Clutch

Above figure shows an indexing clutch where the outer ring makes the reciprocating (back and forth) motion and the inner ring carries out the indexed feed.

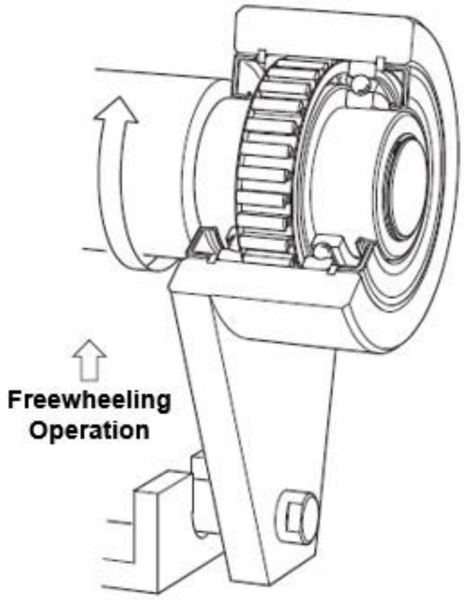

Use of Indexing Clutch in Filling Plant

Indexing clutches are used in metal stamping, press working, packing machines, assembling machines, printing machines, filling plant, etc. For example, above figure shows Use of an indexing clutch in a filling plant.

Backstops/Holdbacks

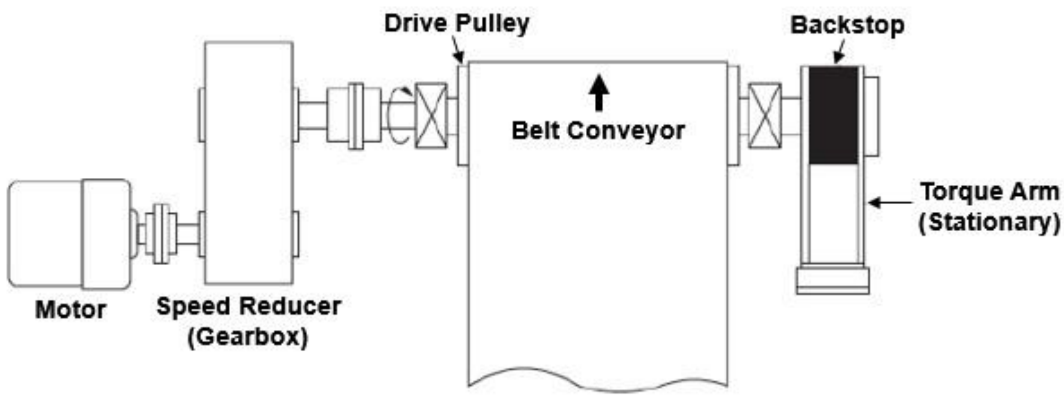
Freewheels are used as backstops if reverse rotation of the operating direction is to be prevented (i.e. to permit rotation in one direction only). The normal operating mode of a backstop is freewheeling operation; the locking (torque transmission) is performed if the drive is disconnected (at zero speed) to prevent its reverse rotation.

Although the freewheel normally overruns most of the time, it is referred to as a backstop or holdback in conveyors, gear reducers and similar equipment because its function is to prevent reverse rotation. At zero speed the overrunning clutch acts as a brake.



Construction of Typical Backstop

In general, as shown in above figure, backstops are used where the inner ring freewheels and the stationary held outer ring prevents reverse rotation. It may be noted that for use as backstop, one race is always fixed to a stationary ground member.

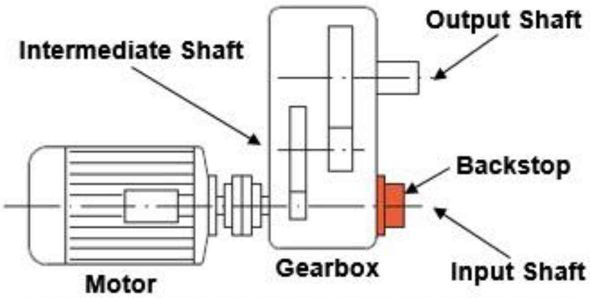


Backstop Installed on Extended Head Shaft (Drive Pulley) of Incline Conveyor

Backstops are used in inclined conveyors, bucket elevators, pumps, fans, etc. Above schematic figure shows use of a backstop installed directly on the extended head shaft (or drive pulley) of an incline conveyor.

Incline conveyor systems require a mechanical safety device for their operation. When the running conveyor with material is switched off or when it stops due to interruption of electric power supply, the material being conveyed will be on the belt for partial or full length of such stopped conveyor. The incline conveyor with material on the belt will be in a state of imbalance, if the downward gravity pull on material is more than all the frictional resistances of conveyor. Unless prevented by mechanical means, such conveyor will start to move backward, i.e. the belt along with material will move from discharge ends to feed end. Now, the feed end is incapable to take the material back. This will cause material spillage / pile up at tail end. This occurrence may result into damage to the belt and machinery at tail end and will be a serious safety hazard. In view of this, to prevent running back of a conveyor, a backstop (often called a holdback) is provided in it.

Because backstops permit travel of the conveyor only in the forward direction, they cannot be used on reversing conveyors or on declined (regenerative) conveyors. In these cases, a brake must be used.



Backstop Installation at High Speed Location

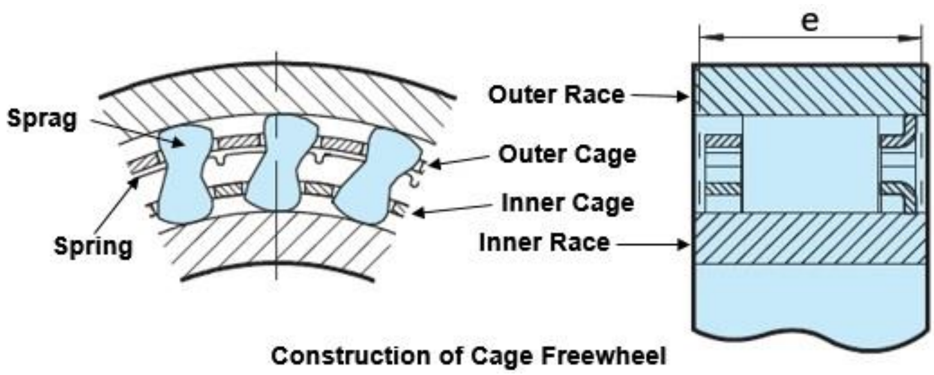
As speed increases, the torque required to maintain the given load decreases. Hence at high speed location, a small backstop can be used because a backstop installed at high speed location required to withstand comparatively small torque. In view of this, as shown in above figure, many times, a backstop is installation at high speed location (input shaft or intermediate shaft of a gearbox) in the drive and thereby economy in design.

However, it may be noted that in case of failure of any part of the drive between the head shaft (or drive pulley) and a high speed shaft (input shaft or intermediate shaft), backstop can cause a reversed runaway condition. Maximum protection against such reversed runaways can be obtained only when backstop is installed on low speed drive pulley shaft where the reverse torque originates and where such backstops can function instantly. In some installations it may be physically impossible to locate the backstop on the pulley shaft. In these cases, the alternate location could be on the double extended low speed shaft (output shaft) of the gearbox.

Cage Freewheels

Cage Freewheel

A sprag freewheel without outer and inner rings is generally called a cage freewheel or DC (Double Cage) sprag freewheel. Cage freewheels are precision and compact devices with individually spring loaded sprags which transmit high torques within a small space. Cage freewheels are often used as backstop/holdback in conveyors due to compact construction and high torque capacity.



Construction of Cage Freewheel

As shown in above figure, cage freewheels consist of individual sprags, a ribbon spring, an outer cage and an inner cage. The sprags are precision made from a wear resisting chrome alloy steel. A specially formed ribbon spring is used to energize the sprags individually and align them axially. The inner and outer cages are made from high grade steel and hardened. The spring ensures optimum energization of sprags and it also holds the sprags and cages together before mounting. The use of double cage construction ensures that all the sprags share the load equally and it is impossible for a single sprag to fail due to overload. Direction of freewheeling can be changed easily by putting the cage freewheel into races in opposite direction. The torque transmission capacity can be increased by installing several cage freewheels side by side.

Since cage freewheels are not having inner and outer races, they must be installed in a design providing races, bearing support for axial and radial loads, lubrication and sealing. Readymade races are also available for use with cage freewheels.

Design Consideration for Races

While designing the inner and outer races, diameters and tolerances should confirm to the sizes recommended by the freewheel manufacturer. It is also very important to maintain minimum wall thickness for the races as per the manufacturer’s recommendation.

For the cage freewheel to function correctly, as shown in above figure, ensure that the inner and outer races are having a minimum plain width “e”, without any recess (for dimension “e”, please refer manufacturer’s catalogue).

A chamfer of 30° and 2 mm long on inner and outer races may be provided to facilitate the assembly of cage freewheel in the races.

Races can be made in case hardened steel shafts, or housings, to the following specification.

- Surface hardness of the finished part should be HRC 60 to 62, for a depth of 0.6 mm (0.024”) minimum.
- Core hardness should be HRC 35 to 45.
- Surface roughness should not exceed Ra 22 µm.
- Maximum taper between races: 0.007mm (0.0003”) for 25mm (0.984”) width.

Installation (Mounting Instructions)

Shaft and Key Assemblies

Generally, for all freewheel inner races connected to shaft by a key, recommended standard bore tolerance is H7, with keyway to JS10. If no other indication, recommended shaft tolerance is h6 or j6.

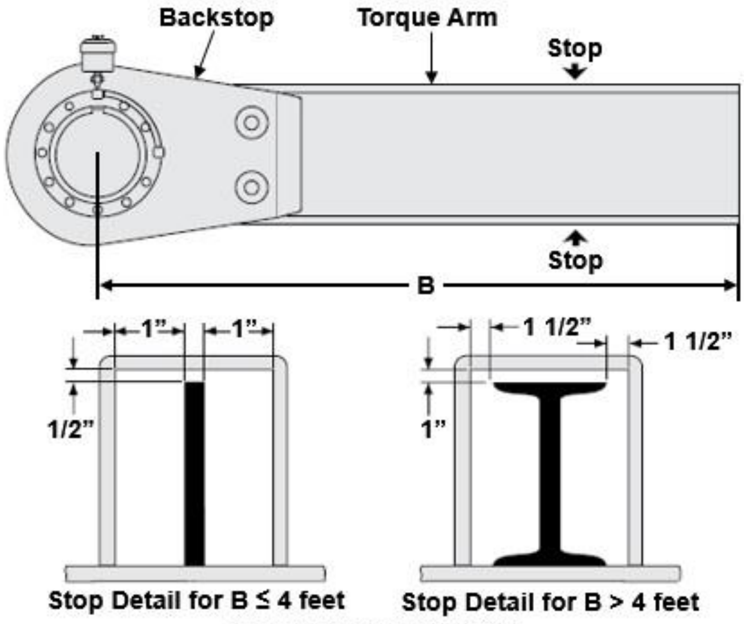
In case of press fit assemblies (never exceed 0.001" interference fit), if specified, as with standard bearings, suitable tooling must be used for press fitting such that no axial load is transmitted through the inner part of the freewheel during assembly.

Fastening Screws for Connecting Parts

For connecting customer's parts to the outer ring of the freewheel, use quality/grade of fasteners as suggested by the freewheel manufacturer and tighten them to the recommended torque. It has proven that fastening screws of the material quality 8.8 is sufficient. It is also suggested that because of the higher brittleness, screws of quality 12.9 should not be used.

Torque Arm Installation

For use as a backstop, one race of the freewheel is always fixed to a stationary ground member. Generally, the inner ring freewheels and the stationary held outer ring prevents reverse rotation.



Torque Arm Installation

As shown in above figure, many times a torque arm is used to ground the outer ring. In such cases, it is recommended that the stops be at least 3/4 of the distance (B) away from the center line of the backstop/holdback. The backstop should be mounted in an orientation so that the weight of the torque arm will keep the torque arm in constant contact with the reacting surface and structure. The torque arm must not be rigidly fastened at reaction point because clearance is required on all sides of the torque arm to prevent binding which could cause uneven loading of the backstop bearings. It is recommended to have clearance on all sides of the torque arm as per the stop details given in above figure.

Lubrication

Proper lubrication and lubricant maintenance are the most important single maintenance factors for long, effective, trouble-free freewheel operation.

Many models are shipped from the factory prelubricated and ready to install. Some models require lubrication to be added prior to being put into service, and other designs rely on lubrication integral to the application.

Grease lubrication is recommended for applications where: (1) conditions do not permit the type of maintenance required for oil lubricated clutches (2) the clutch is exposed to severe dusty conditions and (3) the clutch is mounted on a vertical shaft.

The oil lubricated freewheels are generally delivered lubricated with a VG 32 oil viscosity if they are sealed, self-contained units.

Freewheels delivered without lubricant are supplied with a protection against corrosion. Before putting a unit into operation, it is necessary to remove the anti-corrosive fluid and to fill the unit with appropriate oil. Generally, for a horizontally mounted unit, the correct oil level is 1/3 of the internal clutch height unless specified.

It is recommended that oils including graphite, molybdenum and EP additives should be avoided.

Use oil / grease as per recommendation of freewheel supplier. In case their recommendation is not available, lubricant as per the following table may be used. As shown in the table, for selection of the proper lubricant for each application, the operating temperature should be used to select the oil viscosity required. The ambient temperature range is included as a guide only.

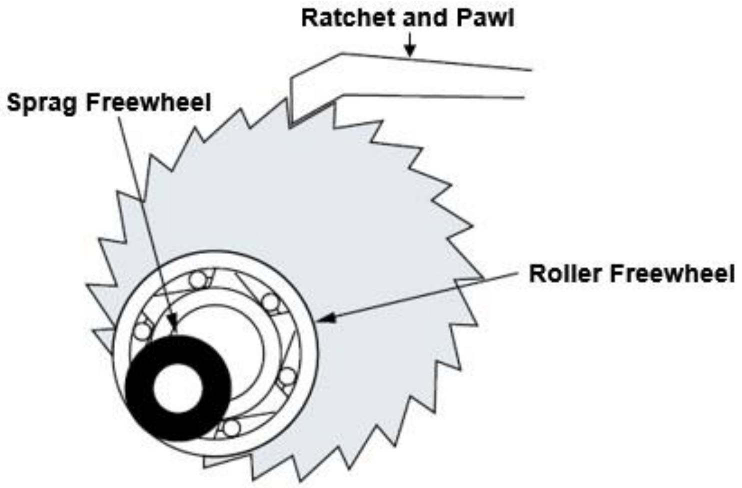
Manufacturer	**Oil**				**Grease**
	Operating Temp. −20°C to +20°C	Operating Temp. +10°C to +50°C	Operating Temp. +40°C to +70°C	Operating Temp. +50°C to +85°C	
	Ambient Temp. −40°C to −15°C	Ambient Temp. −15°C to +15°C	Ambient Temp. +15°C to +30°C	Ambient Temp. +30°C to +50°C	
	ISO-VG (mm^2/s) 10	ISO-VG (mm^2/s) 22	ISO-VG (mm^2/s) 46	ISO-VG (mm^2/s) 100	
ARAL	SUMOROL CM10	SUMOROL CM22	MOTANOL HE 46	DEGOL CL 100 T	ARALUB HL2
BP	ENERGOL CS10	ENERGOL CS22	ENERGOL CS46	ENERGOL RC100	ENERGREASE LS2
Castrol	-	-	AIRCOL PD 46	AIRCOL PD 100	SPHEEROL MP 2
Esso	SPINESSO 10	SPINESSO 22	TERESSTIC T46	NUTO H100	UNIREX N2
FUCHS	RENOLIN MR3	RENOLIN DTA22	RENOLIN DTA46	RENOLIN MR30	RENOLIT LZR2
KLUBER	ISOFLEX PDP 38	ISOFLEX PDP 48	LAMORA HLP 46	LAMORA 100	POLYLUB WH2
MOBIL	VELOCITE No 6	VELOCITE No 10	MOBIL DTE 798	MOBIL DTE OIL HEAVY	POLYREX EM
SHELL	MORLINA 10	MORLINA 22	MORLINA 46	MORLINA 100	ALVANIA RL2
TOTAL	AZZOLA ZS10	AZZOLA ZS22	AZZOLA ZS46	AZZOLA ZS100	MULTIS 2

Alternatively, it is recommended to use multigrade oils SAE 10W-40 at working temperature between 0°C and +80°C.

Initially change the oil after 10 hours of operation. Afterwards change lubricant every 2000 hours and every 1000 hours in a dirty environment.

Unless specified, generally no maintenance is required for units delivered lubricated with grease. However, to increase the service life of units it is recommend to remove, clean, inspect and re-grease them after two years of operation.

Ratchet and Pawl



Size Comparison of Ratchet and Pawl with Freewheels

The ratchet and pawl is the oldest and most common device for indexing and backstopping. However, it is severely limited by the pitch of the teeth, and by centrifugal forces acting on the pawl. To reduce motion, tooth pitch must be reduced which makes a weaker tooth, with resultant low torque capacity. The effect of smaller tooth pitch on torque capacity can be offset by using multiple pawls, but this makes a more complex, cumbersome installation. Above figure compares assembly size of ratchet and pawl assemblies with sprag and roller type freewheels.

References

Freewheels (Edition 2017/2018) by Ringspann (www.ringspann.de)

Overrunning Clutches and Backstops by Stieber (www.stieberclutch.com), The Brand of Altra Industrial Motion.

Overrunning, Indexing, Backstopping Clutches by Formsprag Clutch (www.formsprag.com), The Brand of Altra Industrial Motion.

Backstop Cam Clutch Products by U.S. Tsubaki Power Transmission, LLC (www.ustsubaki.com)

Sprag Type Freewheel Clutches by GMN (www.gmnbt.com)

Freewheels, Sprag and Trapped Roller Clutches by Renold (www.renold.com)