Heavy Machinery

By

Dr. Ahmad Muneer El-Deen

المدرس الدكتور أحمد منير الدين

Drilling Technology Division

4th Year

2018-2019

Second Semester

Mechanical Engineering Department

Faculty of Engineering

Mustansiriyah University

Lecture Notes 5

Lecture 5: Track Drive Undercarriage & Working Attachments

Key Terms

- **Attack Angle:** The angle formed between an imaginary line drawn across the top track and it's intersection point on the ground; also called angle of approach.
- **Belleville Washers:** Cone-shaped spring-steel washers. Belleville washers are located at each end of the track pin in the link counter-bore area.
- **Benjamin Holt:** The industrialist who first developed the practical use of crawler-type track drive systems in North America.
- **Carrier or Idler Rollers:** Rollers that do not support machine weight but carry the track at the top.
- **Case Extended Life Track (CELT):** A dual bushing system doubles track life using a second hardened bushing over an inner bushing and pin. It also uses longer track pins, track links that are wider and have a taller rail on which the rollers ride.
- **Cross-Drive Transmission:** A type of transmission that incorporates a steering mechanism with the drive system. Because there are three differentials incorporated into the transmission, skid steering is also called triple differential steering.
- **Differential Steering:** A steering mechanism in which one track is driven faster than the other in order to control machine direction.
- **Drawbar Capacity:** A tracked machine's performance measurement of the amount of weight a track drive can pull at a given speed.
- **Dual Bushing Track (DBT):** Refers to a construction technique using a double bushing with a hardened outer bushing rotating freely around the inner bushing. No lubricant is present between the two outer bushings. However, an oil-lubricated track pin rotates inside the inner bushing.
- **Elevated Sprocket:** A track system using two idler wheels and a drive sprocket located above the level of the idler wheels. An elevated sprocket system forms a triangular, rather than oval-shaped, track.
- **Equalizer Bar:** A bar connecting two opposite track frames that functions as a weight transfer lever connection point between the two frames. Because the equalizer bar pinned in the center to the main frame it causes a weight transfer from one track to the other as it lifts and passes over an obstacle.

- **"Flatted" Condition:** Flattening is evident when one side of a track roller is worn away from continual sliding friction with the chain link rail.
- **Floating:** Term describing the transfer of a heavy machine between worksites on a flat semitrailer or specialized gooseneck trailers.
- **Friction Drive:** A track drive systems using only adhesive friction between a rubber track and a rubberized or pneumatic drive wheel to rotate the track.
- **Greased Turns:** Involve lubricating track pins with grease during a pin turning service operation.
- **Ground Pressure:** The force exerted by the tires or track of a machine. It is a function of the machine weight divided by the surface area below the tire or track. Ground pressure is measured in pounds per square inch.
- **Grousers:** Wedges or bars on steel track that function like cleats on athletic shoes. These steel bars penetrate the ground surface, providing even more surface area to push or pull against the ground.
- **Holt Manufacturing Company:** The company that merged with Best Manufacturing and incorporated into the Caterpillar Tractor Company.
- **Hunting Tooth Arrangement:** A final drive tooth pattern using an odd number of sprocket teeth to match an even number of bushing. In track systems, the odd–even change in the ratio between the tooth sprocket and track chain bushings ensures there is a change in tooth-to-bushing contact with every sprocket revolution.
- **Hydrostatic, or "Hystat," Drive Dystems:** Machines using hydraulic motors to propel a machine. Hydraulic motors are typically located in the wheel ends or in the final drive assemblies. The motors are driven by hydraulic pumps connected to an engine or electric motor.
- **Idler Wheels or Idler Sprockets:** Large non-driving wheels or sprockets used to loop the track around the track frame. At least one idler wheel or sprockets is used on each side of the machine and located opposite the drive sprocket on the track frame.
- **Interference Fit:** A machinist's term describing an assembly technique where a machined part has a slightly larger diameter than the diameter of the bore where it's installed. On track systems, an interference fit exists between the track bushing and counterbore of the track link.
- **Laterals:** Hand-operated levers used by early differential steering systems to apply a brake to one or both tracks of a machine in order to steer the machine.

- **Metal-Reinforced Rubber or Metal-Embedded Rubber Tracks (MERT):** A rubber track construction technique that adds strength, durability, and stability to rubber track, using heavily reinforced track carcass with steel cables and wire plies.
- **Packing:** A condition where ground materials stick and accumulate between sprockets, track, rollers, and other mating components during operation. Packing increases track tension and track component wear.
- **Pin Turning:** A service procedure where track pins and bushings are disassembled and turned 180 degrees apart before reassembling. Turning can restore proper operating clearances between pins and bushings.
- **Pivot Shaft:** A large weight-bearing shaft that runs from one suspended track frame to the other through the machine's main frame to connect the track frames to one another. Shock loads from the track are transmitted through the pivot shaft to the opposite track.
- **Pivot Turn:** A special movement of a track machine where it turns around its own center point by allowing one track to drive while braking the opposite track.
- **Parallel Link Undercarriage System (PLUS):** The Komatsu PLUS system used on lighter machines does not use dual bushings, but instead enables the bushing to rotate in an oil-lubricated track link counter-bore. Because neither the bushing nor the pin uses an interference fit to retain the parts in the link, only a snap ring is used to lock the pin in place to prevent it from sliding out from between the track links. The use of oil to lubricate the pins and bushings in link counter-bores requires four rather than two separate oil seals.
- **Positive Drive:** A category of track drive system that uses a gear-like sprocket to engage a drive lug or bushing in the track. Positive drive systems are common in earth moving equipment where very high drive torque is required.
- **Recoil Spring Mechanism:** A mechanism used to adjust track tension and absorb shock loads applied to the track.
- **Rigid Frames:** An undercarriage track frame arrangement that uses solid attachment points of the track frame to the main frame that allows no movement between the two frames.
- **Root or Radial Wear:** The name given to sprocket tooth wear caused by the outside diameter of a bushing as it scrubs through the sprocket tooth root.
- **Sealed Track Chain:** A track pin and bushing assembly technique using a nonlubricated track pin and bushing design. The pin operates like a hinge inside the bushing, and

washers at each end of the pin prevent dirt from entering the space between the pin and bushing.

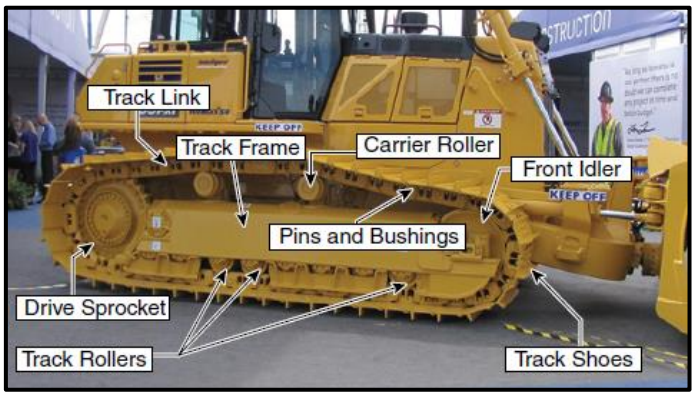
- **Segmented Sprockets:** A type of final drive sprocket formed by bolting pieces or segments of sprocket teeth together. Segments consist of between three and six teeth that, when bolted together with other pieces, form an entire drive sprocket.
- **Suspended Track Frames:** An undercarriage track frame that allow some oscillation of the two track frames relative to one another. A three-point attachment system is used.
- **Thrown Track:** A condition when tracks separate from a machine by riding off worn rollers wheels, chains, idlers, or sprockets.
- **Tiller:** A joystick used to control the steering functions of a track machine.
- **Track Pitch:** The dimension between the track pins.
- **Travel System:** An alternative term used to describe a track drive system on excavators. The term "travel system" is used to differentiate the propulsion system from the undercarriage and associated components used on other machines.
- **Triple Differential Steering:** Another name for a cross-drive transmission that incorporated three different drive differentials to transmit power to track and steer the machine.
- **Wet Turn:** Lubricating track pins with oil, rather than grease, during a pin turning service operation.

Introduction

Track drive undercarriage systems enable off-road equipment to travel and operate over soft, uneven, rugged ground conditions encountered working in farm fields, forests, mines, quarries, or earth moving. Track systems not only enable machines to manoeuvre well but also supply extra traction force for pushing or pulling heavy loads without sinking or allowing significant traction slip. Understanding the function, operation, and construction of track components provides the foundation to identify wear factors, analyse wear patterns through various inspections, perform services, and recommend track maintenance.

What Is Track Drive Undercarriage?

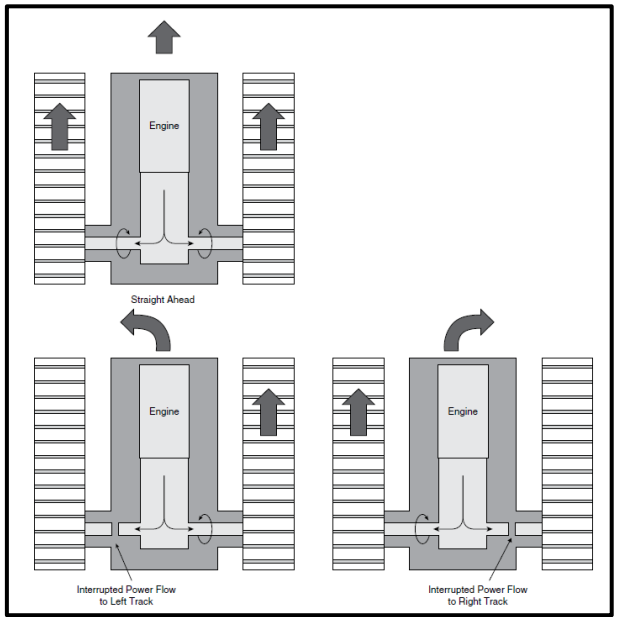
The term "undercarriage" is the generic name given to all the components making up the propulsion mechanism or travel system for track drive equipment. With its conveyor belt-like propulsion system, track drive **undercarriage** is the most recognizable feature on countless variations of dozers, farm tractors, excavators, cranes, compact skid steer loaders, road building equipment, and even military tanks.



What makes this undercarriage system so popular is that it uses a continuously revolving belt made of either rubber or steel plates that enables machines to move or crawl over ground surfaces where wheeled equipment cannot be satisfactorily used. Because track drives have more ground contact area to distribute machine weight, tracked equipment will not sink into soft ground surfaces where wheeled equipment would easily become stuck. More ground surface contact with moving track belts containing cleat-like features also translates into superior traction force compared to wheeled equipment. Superior traction capabilities; greater pulling, digging, or pushing force to move material; and a rugged track drive undercarriage give off-road equipment enhanced working capabilities that no other propulsion system can match.

Advantages of Track Drives

The superior traction ability of tracked undercarriage is enhanced by using one or more **grousers** in track plates. Grousers are wedges or bars on steel track that function like cleats on athletic shoes. These steel bars penetrate the ground surface, providing even more surface area to push or pull against the ground. Wheeled vehicles are much more likely to spin tires if the rolling resistance in soft ground becomes excessive. However, the superior traction capabilities of track drives are demonstrated when bulldozers pull wheel loaders or other vehicles become stuck in mud or soft ground. The same traction capabilities enable bulldozers to operate on slopes with much steeper angles because the traction capabilities, combined with a track drive machine's lower centre of gravity, can overcome greater rolling resistances when excavating, pushing, or pulling heavy loads. In fact, maximum side slope and fore-aft working angles are typically between 30 and 45 degrees. In contrast, side slope work for wheel loaders is typically limited to 15 degrees. When climbing, tracked machines can ascend a hill as steep as 60 degrees compared to 30 degrees for wheel loaders.



Because track drives use a steering mechanism that changes the drive torque applied to each track, they are more manoeuvrable. By driving the tracks at different speeds, the operator can steer the machine in any direction. Smaller turning radius is obtained by driving the tracks in opposite directions, which enables the machine to rotate around its own centre point without forward or backward movement. Long tracks also help smooth out the rough bumps and small obstacles for even better maneuverability. Tracks also enable machines to cross ditches or trenches and highly uneven terrain. In fact, driving a long, fast tracked machine feels more like riding in a boat over heavy swells. When steel track is used rather

than rubber tires, the track cannot be punctured or torn by sharp hard objects struck with high-impact loads. And if a track is broken, with the correct tools it can be repaired without the need to move it to a specialized facility—a feature that is crucial in military tracked tanks.

Disadvantages of Track Undercarriage

The greater mechanical complexity and weight of steel tracks are the primary weaknesses of tracked machines. In comparison to wheeled machines, track drives have a lower top speed and a much shorter service life before requiring costly, labor-intensive overhaul. Slower travel speeds means the machine is not as productive in applications where a lot of machine travel on a worksite is required. Increasing speed results in accelerated track wear. More significantly, increased machine speed means the maximum **drawbar capacity**—that is, the amount of weight a track drive can pull at a given speed—falls off with increased travel speed. Drawbar capacity drops because track rolling resistance increases proportionally with speed while the transmission gear reduction ratio simultaneously drops in higher gears, resulting in reduced torque output. Moving tracked equipment between worksites is another problem. Rather than drive a tracked machine over a road to a worksite like wheeled equipment, the machines are typically floated which means transporting using a specialized trailer. **Floating** is the term describing the transfer of a heavy machine between worksites on a flat semi-trailer or specialized gooseneck trailers. While floating is cumbersome, it is necessary to speed up machine transfer between job sites and reduce unnecessary undercarriage wear.

Packing, a condition where, ground materials can stick and accumulate between sprockets, track, rollers, and other mating components during operation, is inevitable in many worksite applications. Not only does packing prevent parts from engaging correctly, it causes tracks to tighten, which in turn accelerates track wear and requires more engine power to maintain machine speed. Daily cleaning of track components, regular inspection of track tension or track adjustment can minimize the detrimental effects of packing. The use of steel rather than rubber track enables track to withstand high-impact forces encountered working on rock or hard concrete. But steel track grousers damage asphalt and other sensitive surfaces traversed by tracks. Rubberized pads can be attached to track shoes to minimize damage while allowing smoother, quieter, and faster movement on paved surfaces.

Although exceedingly tough, steel or rubber track drives may not be as reliable as wheeled equipment. The loss of a tire, or even more than one tire, may allow a wheeled

machine to move, but a track drive is completely immobilized if even a track link or pin becomes broken. A condition called a **thrown track** can also occur when tracks ride off worn rollers wheels, chains, idlers, or sprockets. Tracks can also become jammed to the point where it requires labor-intensive work to separate before undertaking a repair. Pins and chains on older track can rust and seize if allowed to sit and will require downtime, a lot of lubricant, and labor-intensive work to free. On lubricated sealed pins, heating torches cannot be used to loosen seized track without damaging oil and grease seals. See **TABLE 41-1** to compare the advantages of track and wheeled equipment.

Track-Preferred Jobs	Tire-Preferred Jobs
High traction force	Low traction force
Short push or travel distance	Long push or travel distance
Muddy, soft, unstable ground condition	Stable, firm ground condition
Steep side slope	High maneuverability in confined place
Lifting and loading heavy unstable product	Fast travel speed

Track Drive Components and Operation

Track drive equipment uses two types of drive systems to transfer engine torque to the track. One system, called the **friction drive**, uses friction between the track and a rubberized drive wheel to rotate the track, which in turn moves the machine. The drive wheels on friction drive systems operate like a tire to rotate the track. Friction drives are potentially able to travel faster and more smoothly and quietly, and are commonly used with rubber track belt systems.

The other major category of drive is a **positive drive** system, which uses a gear-like sprocket to engage a drive lug or bushing in the track. Positive drive systems are common in earth-moving equipment where very high drive torque is required. Both rubber and steel track can use positive drive systems.

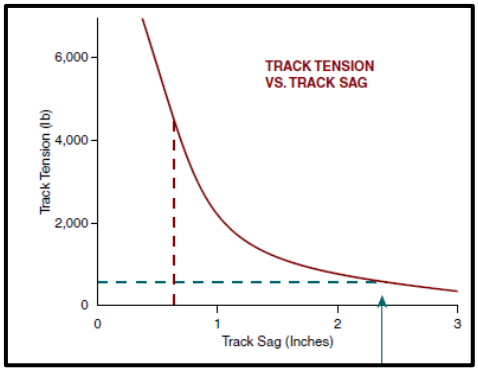
Simple Sprocket Drive Operation

The operation of a positive drive system like those used by steel track undercarriage system has a lot in common with a simple bicycle chain drive mechanism. On a bicycle, the front gear sprocket turned by the cyclist transmits drive torque to a chain that engages a sprocket on the rear wheel. Likewise, a track drive system also has a drive sprocket that engages a chain used to transmit drive torque supplied by an engine. The chain of a track

drive isn't as visible as it is on a bicycle, though, because the chain bolts directly to metal plates called track shoes. Turning the sprocket engaged with the track chain pulls the chain that is securely attached to track shoes. Moving the track shoes produces the crawler-like track travel to take place. The combination of chain and track shoe operates like both a self-laying rail system and a road for the machine to crawl over. The lower rollers on the track frame transfer machine weight to the chain links and in turn onto the track shoes in contact with the ground.

Steel track shoes can be replaced by a rubber belt, where the simple sprocket drive principle of metal track still applies to rubber track operation. Either a drive sprocket engages indentations in the belt called cams to produce belt rotation, or a drive wheel transfers torque through friction with the inside surface of the belt.

To create a continuous return of chain to the drive sprocket, a large idler wheel or idler sprocket is located opposite the drive sprocket. It's important to note that the idler is at the front of the track drive, whereas the drive sprocket is at the rear in terms of forward travel direction. The idler sprocket or wheel is non-driving and functions to create an oval track loop. Looping the chain around the large idler wheel or non-driving idler sprocket creates a return path for the track chain. At least one idler sprocket or wheel is used on a track drive. The size of the idler may be the same or smaller than the drive sprocket depending on a variety of factors such as the position of the drive sprocket, the machine operators need to maintain site lines and the machine's ground clearance. A track tensioning mechanism is attached to the idler sprocket that is used to adjust and maintain some track slack. Without the track tensioner, the track can become too loose from wear and may run off the guide rollers and the sprocket. The track can also become too tight in some circumstances and require loosening using the tensioning mechanism. A tight track adds additional friction or drag force into the chain, which in turn increases the amount of power required by the engine to move the machine. With increased friction, wear in all track components accelerates while travel speed and the power to perform work drops.



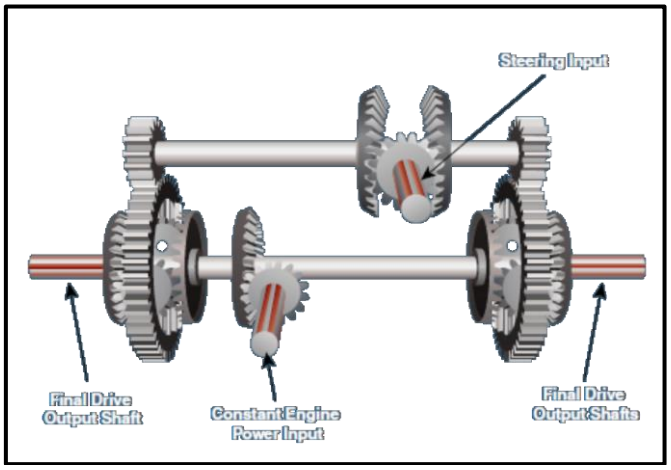
Rollers located on the inside radius of the track loop guide and support the weight of the track and transfer machine weight to the ground. Top rollers are often called idler or carrier rollers because they only guide and support the weight of the top track chain loop to keep it from drooping. Fewer top idler rollers are used compared to the lower track rollers that transfer machine weight to the ground.

Track Drive Steering

There is no steering wheel or steering linkage in track drive machines. Instead, one track is driven faster than the other, pushing the machine in the direction toward the slower or stopped track. Because the leading and trailing edges of the track slide sideways to steer the machine, that sliding action lends the name **skid steering** to this type of steering principle. However, the more accurate term for track steering principle is **differential steering**. Several methods are used to steer machines using skid steer principles. The simplest system used on older, mid-sized machines incorporates a brake and clutch mechanism at each final drive. Hand levers and/or a set of foot-operated pedals control the clutch and friction brake on side of the machine. The clutch and brake mechanism either brakes the final driveshaft or applies torque. The planetary gear outputs in the final drives either speed up or slow down in response to both foot pedals released, clutches transmit torque that is applied evenly to each track. Partially depressing a pedal disengages the drive clutch; fully depressing the pedal applies the brake, effectively locking the transmission output shaft to the frame. If one pedal is partially or fully depressed, releasing the opposite pedal applies torque to track with the released pedal and starts a turn; applying a brake through a lateral lever or foot pedal brake also slows one track and causes the machine to turn.

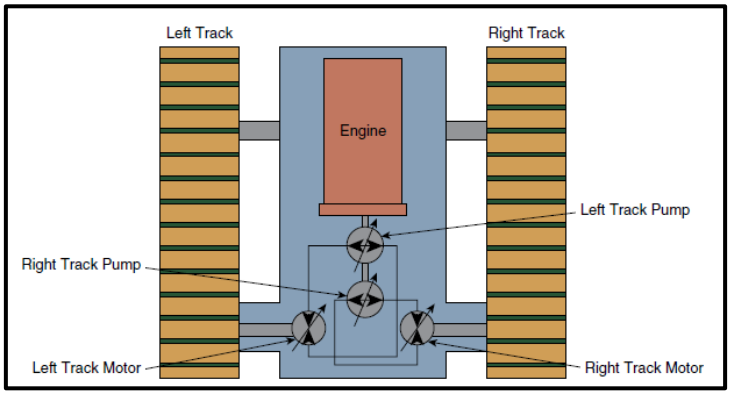
In larger machines, a **cross-drive transmission** is used to control steering. Because there are three differentials incorporated into the transmission, skid steering is also called **triple differential steering**. A cross-drive transmission is the most contemporary type of track drive transmission enabling precise, energy-efficient steering function. It connects track to the engine, continuously operating at working speed while varying road speeds and amount of torque applied to the left or right final drive sprocket. The transmission has two input shafts—one from the engine flywheel and another from a hydraulic or electric motor used for a steering input. Two output shafts connect the transmission to the final drive sprockets. Turning the steering input shaft either clockwise or counterclockwise controls the torque supplied to each final drive. If no input is received from the steering input shaft, both tracks

turn at the same speed. A clutch engages and disengages the engine when no drive is requested, such as when the machine is parked or stopped.



A cross-drive transmission can completely stop the machine track movement, lock the speed of both tracks together, increase the speed of one track, or stop one track and turn the other. A **pivot turn** of a tracked machine stops one track while driving the opposite.

Most midrange larger machines today use electronically controlled **hydrostatic, or "hystat," drive systems**. Whether it is using a hystat drive or cross-drive transmission, steering input can be controlled several ways. The most contemporary method is "arcade" steering that uses a joystick with electronic outputs. Also called a **tiller**, the lever's outputs are connected to an engine control module which in turn controls one or two hydraulic servo motors regulating power flows through the cross-drive transmission. An arcade type stick controls electrohydraulic valves at hydraulic pumps and motors of a hystat steering system. The operator controls machine speed and direction with a joystick, with the neutral stick center placing the machine in a stopped position.



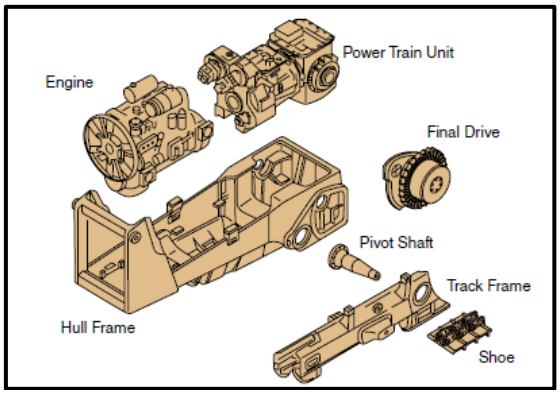
Steel Track Undercarriage

Two major sections of a track undercarriage include the track frame, or side frame as it is sometimes called, and the track components themselves. Depending on the application—

whether it is used as a dozer, asphalt spreader, excavator, or farm tractor in heavy, medium, or light duty—there is considerable variation in the configuration of track components to best adapt a machine for the work it performs. However, the following is a brief description of steel track components common to all track machinery. After identifying the common components in the next section, this chapter takes a more detailed look at various design and operating features of steel track.

Major Track Components

To differentiate a track drive system on excavators from other machines, the undercarriage and associated components on excavators are referred to as the **travel system**. However, excavators and other track drive machines share similar track system construction. For all track machines, the undercarriage backbone is the track frame. Also called a roller frame, as track rollers are attached to it, the track frame is essentially two, relatively large, forged cast steel or fabricated steel frame components located on each side of the main chassis. A track tensioning mechanism that acts through the idler wheel is usually located inside the hollow track frame. The type of attachment between the track and the machine's main frame varies with the application. Some track frames are rigidly attached to the main frame of the machine, whereas others allow some oscillation or vertical articulation—that is, some up and down movement of the track frame at the front of the track. The frame also provides an attachment point for all the track drive components except the final drive unit and drive sprocket.



The track itself is made of several separate components assembled together and includes the following common elements:

1. Track chains are the foundational component of a track drive system. Chains essentially transmit torque to the track from the machine's drive sprocket and provide an attachment point for track shoes. The chain also functions like a self-laying rail system or road over

which the machine crawls. Each chain segment is assembled from two track links connected in parallel to form two rows. The links on each side of the chain are connected using hardened steel pins. Track rollers make contact with the links to transfer machine weight through the link to track shoes also bolted to the links. A section of chain consists of four links forming each side of the chain, plus a pin and a cylindrical bushing that covers each of the pin. The longer pin passes through the ends of each pair of links locking together the two outside links. The shorter bushing is typically pressed into two ends of the inside links and cannot rotate in conventional track. Although the track pin supplies the hinge or articulation point for the track links, it is the chain bushing, made from tough, hardened steel, that contacts the chain's drive sprockets. Track pins rotating inside the bushings enable each chain section to turn or articulate inside the bushing. On all systems, the flat surface on the link rails enables track rollers to contact and guide the chain as it rotates around the frame. Like other track parts, steel links are alloyed with metals such as boron or manganese and undergo various hardening and heat treatment such as flame carburizing and quenching to give chains optimum strength and abrasion resistance. A link rail Rockwell hardness of 58–62 is typically achieved through specialized hardening techniques, which makes the link harder than most materials it should encounter. On lighter machines such as excavators with minimal travel distance, a combined pad-link-type track chain combines a chain link and a track pad into single unit. Sprocket drive forces are directly transferred from the sprocket into the massive pad-link unit.

2. Track shoes are the most visible parts of track drive equipment. Shoes are steel plates bolted to the track chain to form one continuous belt of plates. Shoes are made from alloyed steel because it has the ability to resist wear and cutting and to withstand high-impact forces encountered working in hard concrete, rock, or even scrap metal. Track shoe grousers are steel projections used to increase the track grip over a loose ground surface.
3. Track pin bushings are hardened steel sleeves wrapped around the track pins and often have a lubricating film of either oil or grease between the track pin and bushing. It is the bushing wrapped around the track pin that engages the sprocket teeth to transfer the drive torque from the final drive sprocket to the track chain. Although bushings are traditionally not designed to rotate as they move around the drive sprocket, some newer track systems have alloy bushing rotation.

4. Drive sprockets are a toothed wheel mounted on the final drive assembly. It functions to turn the track chain by engaging the track bushing wrapped around the track pins. Drive torque supplied to the sprocket is developed by the engine and transmitted to the final drive through a transmission. There is one drive sprocket for each side of the track, which is located near the rear of the oval-shaped track.
5. Rollers directly contact the track chain links and are used to guide and support the track chain as it revolves around the frame. Most machine weight is transferred to the chain through the rollers. Bottom rollers are attached to the lower side of the frame and support the weight of the machine there is a tremendous amount of weight to support, there are more bottom rollers than top rollers. Upper rollers, also called **carrier** or **idler rollers**, are located on the top side of the track frame. These rollers guide the track and prevent track "whipping" and excessive track sag from contacting the frame while the machine is moving. A rock or roller guard—that is, a steel plate—is often bolted to the track frame to prevent rocks from entering the roller and idler wheel area and jamming the track.
6. **Idler wheels** or **idler sprockets** are large non-driving wheels or sprockets with at least one on each side of the machine and located opposite the drive sprocket on the track frame. The idler is much larger than a roller and shapes the tracks into an oval loop by creating a return path back to the drive sprocket. Working in combination with a track tensioner, the idler also helps minimize transmission of shock loads to the drive sprocket and maintain track tension.
7. Track tensioners, as the name suggests, are used to maintain track tension to prevent the track from running off the rollers if it becomes too loose. The tensioner is connected to the idler wheel and also absorbs some shock loading of the track chain. Tensioners are necessary to compensate for changes to chain length due to wear. Together, rollers, idler wheels, sprockets drives, chains, and chain-tensioning mechanisms are used to stabilize track, that is, to keep the track running straight, and form suspension mechanisms.

Track Frame Systems

The track frame is the backbone of the track system by providing attachment points for almost all the track system components. The frame is shaped like a hollow tube with internal reinforcements. Frame designs are adapted to specific applications. For example, excavators use a longer track frame to provide the machine with better stability when digging. The width of the frame may be wider or narrower, depending on where the machine is working or

digging. For example, frames for dozers and excavators are available in three configurations: standard, extended, and narrow, each with different types of shoes and track lengths.

Track frames may be either suspended or rigid type. **Rigid frames** have solid attachment points to the main frame and allow no movement between the two. This means there is no relative movement between the track frame and main frame. Neither is movement allowed between any lift arm attached to the main frame and the track frame of a rigid-mounted undercarriage. Smaller track drive machines use rigid mount, unlike larger dozers that allow some movement. Rigid mount configurations give a machine's blade or attachments considerably more stability and are best used for machines such as those mostly used for grading or those having a frame attachment such as pipe layers. The rigid mount frame offers simplicity with fewer parts, increasing durability while potentially lowering maintenance cost.

Suspended track frames allow some oscillation of the two frames relative to one another. A three-point attachment system is used. Near the rear of the frame but ahead of the final drive, a **pivot shaft** runs from one frame to the other through the machine's main frame in order to connect the track frames to one another. Shock loads from the track are transmitted through the pivot shaft throughout the case of the machine's main frame. This setup minimizes the bending stresses applied to just the sides of a machine's main frame in rigid mount systems. The pivot shaft typically has an oil-filled plain-type bearing at each end of the track frame to enable free vertical movement of the front of the track. The pivot shaft also functions to help keep the track frames properly aligned.

At the front of each track frame is also a connection point to an **equalizer bar** pinned in the centre to the main frame. A heavy bushing or bearing connects the track frame to the equalizer bar. If one side of the track is lifted passing over an obstacle, some of the weight is transferred to the opposite track frame by the pivoting equalizer bar. This lever-like weight transfer through the equalizer bar minimizes the tendency of the machine to excessively roll when encountering large bumps or ground depressions, which helps maintain machine stability. However, blades and other attachments move with the track frame, using suspended frames. Side thrust loads against the track frames are absorbed by large steel track guide plates on the main frame. These contact points keep track frames properly aligned during frame oscillation. Thus the ability of track frames to oscillate up or down enables track to better match ground contours while providing for improved traction, slightly faster travel speeds, and better operator comfort.

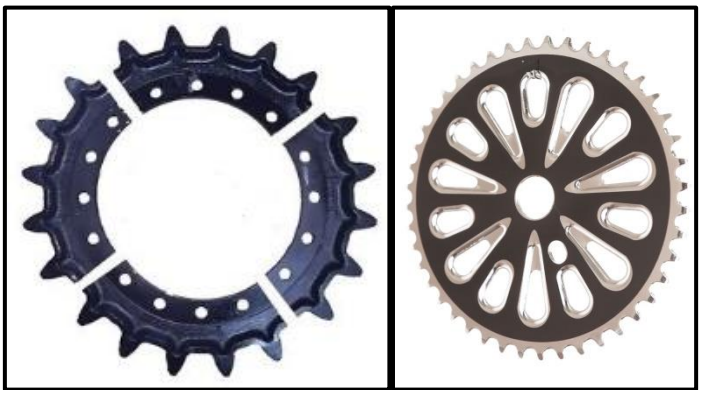
Track Undercarriage Arrangements

Track drives can be classified several other ways in addition to the method of frame attachment systems. Other classifications include:

Drive sprocket arrangement, Track chain and bushing configuration, Track roller configuration.

Drive Sprocket Design

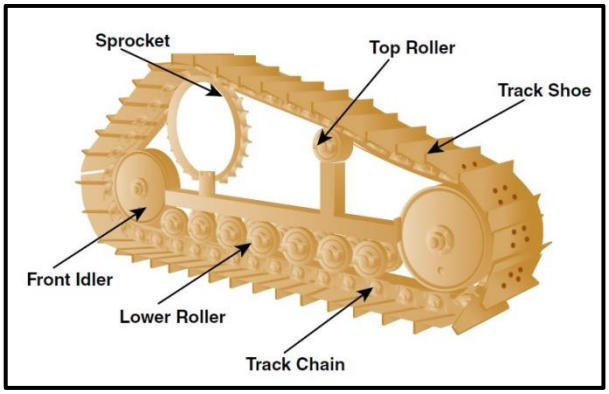
The type and position of the drive sprocket influence weight distribution, rates of track wear, and service procedures used in maintaining undercarriage systems. The primary function of the sprocket is to transfer drive torque to the track chain through teeth on the sprocket circumference. The sprocket and final drive are never mounted on the track frame. This arrangement minimizes transmission of shock loads into the final drive from the track. Contemporary sprockets are made from wear-resistant hardened steel segments that are bolted to the final drive in order to enable a rapid parts change-out. This eventually happens as sprocket teeth become excessively worn due to the continual grinding of abrasives between the sprocket and chain bushings. **Segmented sprockets**, which are formed by bolting segments of sprocket teeth made of between three and six teeth, form an entire drive sprocket. Considerable downtime and labor is saved using segmented sprockets. Rather than using a hydraulic puller to pull a splined drive sprocket from the final driver, or cutting off an older one-piece sprocket and rewelding another in its place, a segmented sprocket simply bolts to the final drive plate. Updating older sprockets to new segmented types is also possible. By welding an adapter ring in place of an old, single-piece sprocket, new segmented sprockets are bolted to the adapter ring.



Sprockets commonly use what is termed a **hunting tooth arrangement** of teeth. By using an odd number of sprocket teeth to match an even number of track chain bushings, there is a change in tooth-to-bushing contact with every sprocket revolution. With a hunting tooth arrangement, the same sprocket tooth and chain bushing will not make contact together until all other chain bushings have passed over the same tooth or at least until after several sprocket rotations. This design enables an even distribution of wear among the sprocket teeth.

Elevated Drive Sprockets

Oval-shaped track has been the traditional track configuration where a single drive sprocket is placed at the rear and idler wheel at the front. However, in the 1970s, Caterpillar introduced an **elevated sprocket** that places the drive sprocket above the track frame, giving the track a triangular shape. More commonly referred to as a high-drive track, the design uses two large idler wheels, instead of a single idler, but stretches the bottom section of track between the two idlers to enable better contact between the track and ground. The track remains tighter between the two idlers, unlike oval track drives that allow track to loosen when moving in a reverse direction. When in reverse, backing up a steep hill or embankment, drive sprocket torque on oval tracks tightens the top section of track and allows the excess slack to move to the bottom. The track is at a greater risk of running off the rollers and drive sprocket, particularly when turning as side thrust forces push against the track and rollers.



Elevated drive sprocket keep tracks tight on the ground, whether in reverse or forward, because the loose section of track is either in front of or behind the high drive sprocket. The track remains tight between the front and rear idler sprockets. Removing the transmission is much easier on high-drive track, as is servicing the final drive assembly that is more open. Mud and dirt do not as easily pack a high-drive sprocket, and it shed debris more quickly, so wear is reduced. Operators also have better lines of sight with the triangular track shape.

Most manufacturers have adopted the use of an elevated sprocket design, even though the track needs an additional track segments and another idler sprocket. These slight disadvantages are compensated by greater flexibility to distribute machine weight using different track frames with the elevated sprocket. High-drive sprockets enable the use of different lengths of track frame and flexible positioning of track frame relative to the main machine frame, to minimize the rate of wear on different components. For example, loading using a bucket, dozing, and pushing loads usually shift the machine weight toward the front, increasing weight and wear rates on the front rollers and idlers. Using a ripper or pulling with

a drawbar shifts the weight toward the rear, accelerating wear on the rear rollers, idlers, and drive sprockets. When a machine carries loads in both a bucket and dozes, and then changes to a task shifting weight from the front to the rear, less wear occurs on the center rollers and more on the front and rear rollers. The ability to move the track frame without repositioning the final drive sprocket or transmission provides a greater flexibility to adjust weight distribution using different track positions.

Three common track frame configurations are used with high-drive sprockets. The first is a standard arrangement. This general-purpose undercarriage balances machine weight evenly on a track frame center aligned with the mid-center point of the machine. A second configuration, the XR arrangement, moves the track frame rearward, which in turn movies the tractor's weight forward to enhance traction and stability for drawbar, skidding, and ripping applications. A third setup, the low ground pressure (LGP) arrangement, moves the frame forward and increases track frame length, along with wider shoes. This track is designed to work in soft and spongy conditions, with better floatation capabilities. The width of the machine is increased with wider shoes, which means it has a wider gauge. Wide track shoes, long track frames, and a wider gauge increase track contact area and reduce ground pressure for improved stability, providing excellent floatation in swampy conditions.

On elevated track, the location of the drive sprocket and idler size can be adapted not only to achieve better weight distribution but also to improve operator sight lines, change the ride characteristics, and improve maneuverability. For example, smaller idler wheels, which provide a sharper curve at the end of the track, can make sharper turns. The disadvantage of a smaller idler is that the track may penetrate softer ground materials farther. The diameter of the front idler changes a dimension called the angle of approach or **attack angle**. These angles are formed between an imaginary line along the top track and the point where it intersects with the ground. The angle should be greater for agricultural applications to prevent machines sinking in soft dirt or mud. Snowplows use a smaller attack or angle of approach to better penetrate snow and lower machine ground clearance.

Track Chains

The most essential component of a track drive system is the track chain. As already mentioned, a segment of track chain consists of two links, a pin, and a cylindrical bushing that wraps around the pin. Between 30 and 50 segments of links make up a typical track chain on mid to large dozers or loaders. Chains function to transfer final drive torque to the track,

provide a connection point for track shoes, supply a surface for rollers to transfer machine weight to the track while guiding the track, and enable smooth track articulation and flexibility. Because very high driving forces are transmitted through the chain parts when it is continuously exposed to abrasive dirt, sand, and mud, the chain is sensitive to wear and deterioration. What differentiates various chain designs are the construction techniques used to minimize chain wear and assemble the chain. Tractors and excavators have different construction because they have different jobs to perform. Most modern chain systems use lubricant between the pin and bushing. But the type of lubricant, how the lubricant is retained, and the assembly method used to connect the chain segments together are unique to each manufacturer, reflecting different approaches used to reduce chain wear and track maintenance. Four basic chain construction techniques are used, with several variations among different manufactures:

1. Sealed Track Chain (SLT nonlubricated)
2. Sealed and Greased Track Chain (SAGT)
3. Sealed and Lubricated Track (SALT)
4. Rotating Bushing Track.

Sealed Track Chain (SLT Non-lubricated)

Sealed track chain (SLT), the earliest type of chain assembly technique, uses a non-lubricated track pin and bushing design. A solid steel alloy pin rotating inside a cylindrical bushing connects the opposite sides of the chain links together. The pin operates like a hinge inside the bushing, fixed to a different set of links. Pins and bushings use a machined **interference fit** to retain the pin and bushings in the track links. The pin is pressed into one pair of links while the bushing is pressed into the counterbore area of another pair of adjacent links of the track. An interference fit means the pin and bushing diameter is slightly larger than the counterbore in the track link. With interference fit assembly technique, large hydraulic presses, either portable or stationary, are used to press pins and bushings out of track links when track is rebuilt.

Sealed-type track chain earns its name from the use of two cone-shaped spring-steel washers located at each end of the pin in the link counterbore area. Also called **Belleville washers**, these hardened, spring-like metal seals are used to keep abrasive dirt particles from entering the clearance between the pin and bushing. No lubricant is used between the pin and bushing because grease and oil can attract and hold abrasive dirt, which rapidly accelerates wear between the pin and bushing. When

this track has worn out, pins and bushings are pressed out of the links, and new pins and bushing kits are pressed into the links.

SLT chain is ideally used where machine travel is not a priority and is a low-cost alternative to lubricated pins. For example, excavators do not travel as far pushing or pulling heavy loads compared to say a bulldozer, sealed non-lubricated track can be used.

Sealed and Greased Track (SAGT)

Without the use of lubricant, non-lubricated track chain is noisy during operation and can wear rapidly. When it wears out, pins, bushings, and sometimes chain links require replacement. To improve chain life and reduce noise and maintenance cost, most manufacturers use chain that is sealed and lubricated with either oil or grease to extend track life. Similar to non-lubricated sealed chain construction, lubricated track chain minimizes friction between the pin and bushing using grease. Pins are typically cross-drilled and filled with grease, with a second drilled passage intersecting the axial drilled passage that supplies a reservoir of grease for the pin-to-bushing clearance. Steel Belleville washers are replaced with polyurethane type seals to prevent grease from leaking out and dirt from entering into the pin-to-bushing clearances. Lubricated and sealed chains using molybdenum or lithium grease to extend chain life approximately 20–40% compared with non-lubricated track chain. Not only does greased chain lower travel resistance and noise levels, but also maintenance costs are reduced since this chain can reuse pins and bushings even after they are worn out. A service procedure called **pin turning** enables reuse of pins and bushings if the machine has been used in a non-impact conditions. If track has encountered rocky and rough ground, pins can bend and become unsuitable for turning. Turning can be performed on non-lubricated track but is less common since components reach maximum wear limits much faster and it is often more economical to replace pins and bushings than perform a turn. In that situation, track is operated to destruction and simply replaced.

Sealed and Lubricated Track (SALT)

The newest track chains on machines doing a significant amount of traveling use oil lubrication in the pin and bushing joint and allow the bushing to rotate. This design enabling the bushing to rotate is the biggest recent advancement to extend chain life since bushing and sprocket wear is dramatically reduced. Enabling the bushing to rotate in an oil lubricated link counterbore minimizes tooth to bushing friction to the point where 50–70% less wear is

achieved. Caterpillar's System One, introduced in the early 2000s, and Komatsu's Plus tracks are examples of SALT systems. Cat's System One uses a simpler box-shaped track link that is less vulnerable to damage. Rollers and track links also have additional premium track features to extend service life. The idler wheel for example only runs on the track bushings and does not sit on track link rails. Compared to the grease lubricant used in sealed and lubricated track, the oil generally provides longer service life with less pin-to-bushing wear. Oil seals tend to last longer than grease seals since the lip-type seals used with oil lubricant receive better lubrication. Each pin and bushing assembly is sealed and has its own cavity for oil lubrication that is often synthetic oil. Polished bushing ends minimize seal lip wear. Stepped-type bushings, which are thicker in the middle, provide more external wear material. Rigid seal, which consists of a flexible load ring, rigid seal ring, and thrust ring, provides better seal ability in all underfoot conditions, reducing the effects of impact on track joints that cause premature seal failure. The rotating pin and bushing design means there is little internal wear on the joint. And if significant wear does take place, the interval for the turning of the track pins and bushings is much longer because most wear will be on the outside of the bushings and in the track links. When external bushing wear approaches 50% after measuring track pitch and comparing with specifications, a **wet turn** is a service option on SALT track with fixed bushings. The procedure is called a wet turn because oil rather than grease is used as a lubricant. Like a grease turn, a wet turn involves pressing the bushings and pins out of the track and rotating the parts 180 degrees or flipping pins end for end. During a wet turn, refilling the oil cavity uses a method that involves a vacuum pump to draw new oil into the pin through a self-sealing plug in the end of the pin. New oil seals must be installed during a wet turn. Worn or damaged seals prevent pulling a vacuum that indicates the pin seals will leak.

SALT track has plugs, which can be removed to fill pin cavities with oil. The clear plastic plug appears dark when filled with oil, and light when oil has drained from the pin. Oil is retained in the track pin by a rubber stopper and polyurethane plug. The oil is installed in the pin through a hole in the centre of the rubber stopper. When the pin oil cavity is filled, the plug is reinstalled in the stopper.

Rotating Bushing Track

A track design enabling both the bushing and pin to rotate is the biggest advancement to extend chain life since bushing and sprocket wear takes place more evenly over the

surfaces of these parts, and the mechanical factors causing wear are dramatically reduced. Two design methods help minimize wear common to sealed lubricated and non-lubricated track. One method uses a two-piece bushing called a Rotating Bushing Track (RBT). Komatsu pioneered this design, which is called **PLUS (parallel link undercarriage system)**, a track system developed for medium-sized bulldozers and introduced in 2008. A second one for larger machines is called the **dual bushing track (DBT)**. The dual bushing track also uses a double bushing construction in which a hardened outer bushing rotates freely around the inner bushing. Unlike the PLUS system, no lubricant is present between the two outer bushings. However, rotating inside the inner bushing is an oil lubricated track pin. Komatsu field-testing observed that the dual bushing system enabled bushing and sprocket life to increase to over 3,500 hours of operation from 700 hours using standard track configuration. This translates into a 46% increase in track life that compensates for the additional cost of an RBT track system. The Komatsu PLUS system used on lighter machines does not use dual bushings, but instead enables the bushing to rotate in an oil-lubricated track link counterbore. Since neither the bushing or pin use and interference fit to retain the parts in the link, only a snap ring is used to lock the pin in place to prevent it from sliding out from between the track links. The use of oil to lubricate the pins and bushings in link counterbores requires four, rather than two, separate oil seals: a pair to keep dirt from entering the oil cavity and another pair to prevent oil from leaking out of the pin operating clearances. Enabling the bushing to rotate in an oil-lubricated link counterbore minimizes tooth to bushing friction to the point where 50–70% less wear is achieved. Case also uses a similar system, called **case extended life track (CELT)**. This dual bushing system doubles track life, using a second, hardened bushing over an inner bushing and pin. To obtain even longer service life, both track systems also uses longer track pins, track links that are wider and have a taller rail on which the rollers ride. Because the bushings rotate, relative motion between the bushings and the sprocket teeth is almost eliminated. Any wear that does take place distributes evenly around the bushings. This means no bushing turns are required to reestablish correct track pitch, and sprocket segment wear is dramatically reduced.

Track Shoes

Track shoes are formed metal plates bolted to the track chain. Machine weight distributes over the ground contact patch surface area of the shoe plate. Cleat-like protrusions, called the grip grouse or grouser, penetrate the ground to increase the shoe's traction capabilities. Grousers also provide shoes greater bending resistance. More grousers provide the greatest resistance to bending needed in high-impact working conditions, defined as exposure to rock or concrete bumps of 6 inches or more. Holes in the shoes are designed to allow mud, snow, soil, or other material to squeeze through the shoe, and clean material as

the track rotates. The forward edge of the shoe overlaps the shoe ahead of it on the track. A curve built into this leading edge opens when the shoe rotates around the idler or drive sprocket to help clear material buildup.

Shoe design naturally depends on the operational requirements of the machine. For example, a typical standard dozer shoe uses a deep, single grouser to adequately penetrate the ground and provide the traction force necessary to push or pull a load. A more highly maneuverable loader with a hydrostatic drive, enabling operators to turn rapidly and in a small radius, uses two or three low-profile grousers. In this application, smaller grouser profiles allow the track to slip more and reduce stress on track components as the track undergoes tremendous side loading when turning. Ground disturbance is also minimized by low-profile grousers. If a shoe encounters high turning resistance, it may bend or even crack and break. Offsetting the advantage of low-profile grousers is that increased plate wear takes place.

Shoes are rated according to their wear resistance. Although most shoes are heat treated and made from alloyed steel to increase hardness and reduce abrasive wear, faster wear rates are encountered in severe working conditions. Shoes for extreme conditions are made for applications such as ripping in hard ground and working in rocky soil and over concrete. The extreme-service shoes have thicker plates with greater hardness, plus they have taller grousers to compensate for rapid abrasive wear. Thicker, hardened plates impart greater impact resistance.

Chemical effects from soils can undermine the effectiveness of severe-service shoes. For example, salt, calcium and other corrosive minerals accelerate corrosion in hardened steel. Pitting in the shoes creates stress risers that are points where shoes can more easily fracture.

Ground conditions that are extremely soft or in extremely soft or completely penetrable material, such as loose soil, sand, or muddy conditions, is classified as low-impact condition equipment.

Track shoe width typically ranges from 12" to 36", depending on the machine model. Shoe width is adjusted to provide an optimal ground pressure, which depends on matching machine weight to working conditions. Wider shoes reduce ground pressure, which provides a machine better flotation capabilities and less ground disturbance. Working on slopes and performing grading operations with a wide shoe improve blade control. The ride is smoother and machine stability is better. Grouser penetration is reduced with lower ground pressure, which in turn reduces traction.

Track Guidance System

Track rollers and the idler wheel have several functions, but together they maintain track alignment—that is the straight-line movement of the track. Bottom rollers riding over the track chain ensure the track does not squirm around, and top rollers prevent track sag under normal conditions and whipping at high speed. Track guards or roller guards, which are steel plates attached to the track frame on both sides of the bottom rollers, also guide the track and prevent it from slipping off the rollers. The guards function primarily to keep the rocks and foreign debris from getting between the track rollers and track links. But positioned next to the track chain, the guards also help guide the track chain. Guards are especially critical for track guidance and stability when working on side hill operation. It's important to note here that good work practice requires that the area around the track guards be regularly cleaned, particularly after operating in muddy conditions, to prevent accelerated track wear.

Track Rollers

Track rollers are differentiated according to their location and function. When installed on the bottom of the track frame or roller frame, the rollers support the weight of the equipment and distribute it evenly over the section of track contacting the ground. Rollers supporting the weight of the top half of track are called idler or carrier rollers. Because the carrier rollers do not bear as much weight, there are fewer carrier rollers compared to bottom rollers, which are more closely spaced together and mounted to the bottom of the track frame. Because the rollers contact only the track chain links directly through the link rail, a flange on the side of the rollers aligns the chain with the roller.

Most track designs use two different types of bottom rollers: single flange and double flange. Single-flange rollers are used closest to the sprockets or idler wheel, allowing some slight track movement only at those points, to enable smoother engagement of the idler wheel and drive sprocket. With single-flange rollers, the flange is located on the inside edge of the track chain. Double-flange rollers maximize track stability and alignment by minimizing any side-to-side movement of the track link. Twin flanges on both sides of the track link force the track chain to move only in a straight-line direction through the roller flanges. Typically, a combination of single- and double-flanged rollers is arranged alternately on the bottom of track frame. For example, on a Cat D5, the bottom rollers are arranged like this:

Rubber Track

Rubber track drive systems, replacing linked steel plates with a single-piece, metal-reinforced rubber belt, are an increasingly popular alternative to steel track systems. Like steel track, rubber track has better traction and lower ground pressure than wheeled equipment and is ideal for working in loose, muddy, and irregular ground. But rubber's performance is improved over steel track because it uses significantly fewer components, has a less complex design, and disturbs ground much less than steel. Compared to a wheeled machine, rubber track is approximately 15% more expensive to purchase, but long-term maintenance costs are about the same. Rubber tracks are lighter in weight, using a single-piece belt construction that is far less damaging to sensitive surfaces such as lawns, side-walks, and road surfaces. Rubber tracks are also preferred by operators for their lower vibration and noise levels. In operating conditions where ground chemicals can attack steel track, rubber tracks are more resistant to deterioration. In comparison to steel tracks, machines using rubber tracks are lighter and make less noise when traveling. Manufacturers boast that the latest rubber track systems can last 3,000–5,000 hours and double the life of a wheeled machine performing the same work under the same working conditions. The primary disadvantage of rubber track is that it can be damaged in high-impact, highly abrasive operating conditions, such as rock quarries, demolition sites, or when working with scrap metals. Although rubber track systems can travel faster than steel with less wear, they still should be floated between distant worksites. A cooldown period of 30 minutes is needed when doing continuous or extensive travel over concrete and asphalt.

Rubber track systems have been more slowly adopted by equipment operators, accounting for less than 10% of the wheeled and steel track market. In the agriculture market, rubber track systems have as much as 30% of market share of large horsepower tractors. Part of the explanation for the poor take-up is previous belt-like systems, such as those used for half-tracks in World War II, were not as strong and during military actions were easily damaged. Machines in the agricultural market often use four tracks for better weight distri-bution and traction in muddy, wet soil. They have between a 14% and 22% higher cost premium in initial purchase price.

Types of Rubber Track System

Rubber track drives use one of two types of drive systems. The simplest system, called a friction drive, only uses the adhesive friction between the rubber track and a rubberized or

pneumatic drive wheel to rotate the track. Belts run at very high tension to maintain drive friction between the driving wheel and track. In fact, as much as 15,000 pounds of belt tension is typically applied to the belt, using a hydraulic tensioning mechanism. A centre lug in the underside of the tread guides the track between grooves in the idler and drive wheels.

Positive drive rubber tracks use a drive method similar to steel track where a final drive sprocket engages the drive lug or track cog in the tread. Drive motors independently rotate drive sprockets on the left and right side of the undercarriage. Friction and wear between drive sprockets and track lugs can be minimized through the use of two-piece track pins or with rotating steel sleeves on drive sprocket rollers. Wheel-to-track slip found in friction drive track is eliminated in the positive drive system. However, this track and drive system requires more precise manufacturing and tensioning system. Positive drive systems are better adapted to aggressive work requiring high-drive torque such as dozing and using drawbars in agricultural work. Choosing a friction drive over a positive drive system is determined by other factors such as operating cost, travel speed, weight, duty cycle, ground pressure, traction needs, machine life expectation and the machine's application (agricultural, construction, forestry, etc.).

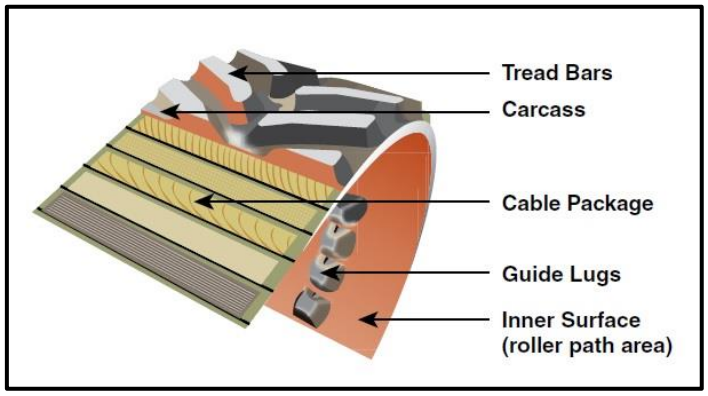
Rubber Track Construction

One set of rubber track, driven by the machine's final drive, is used on each side of a machine to support and drive the machine. Although the construction of rubber track systems and components is different from steel track, there is complete commonality between rubber and steel track operation and function. Like steel track, six basic components are used in rubber track systems:

- Rubber track is a single-piece continuous belt.
- Drive wheels transmit torque to the track.
- Mid-rollers to maintain track alignment and transmit machine weight through the track; Rubber track rollers often use a suspension system to maintain good ground contact and provide a smoother ride.
- A front idler supports track weight, aligns track, and works with a tensioning mechanism to maintain track belt tension.
- A belt tensioning mechanism is used to adjust belt tension and absorb shock loads to the track.
- A track frame is a major frame component that supports track parts.

Rubber Track Belts

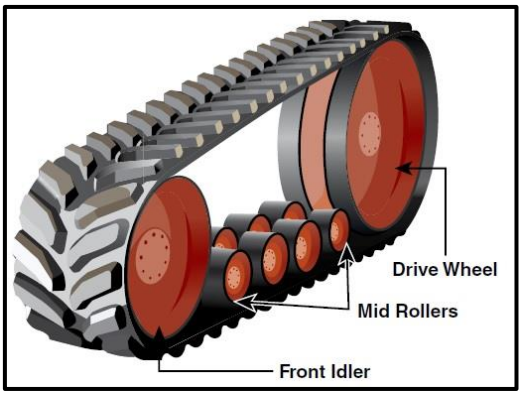
If only rubber were used to construct a track, it would quickly stretch, break, or rapidly wear out. To provide the 3,000- to 5,000-hour life that is double that for tires, rubber track uses specialized construction features. Track strength, durability, and stability are achieved primarily through heavily reinforcing the track carcass with steel cables and wire plies. This kind of construction lends the name **metal-reinforced rubber** or **metal-embedded rubber tracks (MERT)** to rubber track belts. Like tires, the carcass may have several plies of rubber and metal belts. Steel links are embedded into positive drive tracks to provide a solid foundation for track rollers to travel across, plus a point for a drive sprocket to grasp the belt. Thick tread lugs provide maximum traction and long belt service before needing replacement. Tractions lugs may be directional or non-directional, which means technicians must observe whether the track should be installed in a particular way. A series of guide lugs on the side of the track maintain alignment with the drive wheel, rollers, and idler wheel as it rotates around the track frame. In positive drive systems, traction or drive lugs are also used to transfer torque to the belt. In friction drive system the lugs merely guide the track. Friction drive systems are common in paving applications.



Drive Wheels

On all rubber track machines, the drive wheel supplies torque to the track through the machine's final drive. The outer rim of the friction-type drive wheel uses a polyurethane or bonded rubber wheel, often capable of retreading, to provide friction for power transfer to the rubber track. A drive wheel configuration for a positive drive system in some Caterpillar machines uses a two-piece rotating roller sleeve to minimize friction as the rollers engage track lugs on either side of the drive wheel. Like the Cat SALT track used by the system One steel track, a roller bushing sleeve rotates over a stationary inner roller pin. When pin-to-bushing wear does increase, the inner pin will normally wear only on one side because it is

locked in the drive wheel. The free-rotating outer sleeve will evenly wear around its circumference. Cat recommends that when the outer bushing sleeves are replaced, the inner pins should be rotated 180 degrees to "double" their service life. Only one turn is permissible, though. A second replacement cycle requires new pins and bushing.



Mid-Rollers

The mid-rollers, made of polyurethane or rubber bonded to steel wheels, are mounted on the track frame to support machine weight. They are relatively small and close together to provide consistent ground pressure on the track as it revolves and engages the ground. Normally there are two rows of rollers, one row on each side of the guide lugs. A suspension system attached to the mid-rollers enables the track to articulate over uneven surfaces to further improve ground contact and traction. Roller wheels are a wear item and require periodic replacement. Generally, though, worn wheels can continue to function if they have a minimal amount of rubber surface.

Front Idlers and Tensioning Systems

The front idler wheel supports the track as it revolves around the track frame. With the idler is a track tensioning mechanism that operates to absorb shock loads and adjust track tension. The tensioning mechanisms may resemble the grease-operated servo piston types found on steel track or may use simpler spring-type adjustment mechanisms or a gas accumulator hydraulic system, providing a constant, flexible tension on the track.