TRACTION AIDS

Purpose

To describe various traction aid devices that 4WD vehicles are equipped with or may be equipped with

Traction control groups

- Computer Controlled
  - Electronic Traction Control
- Mechanically Controlled
  - Differential lockers
    - Automatic
    - Switchable
      - Electric
      - Air
      - Mechanical
  - Limited slip differentials
  - Spools

Computerized Traction Control

- Developed in Formula One racing to control wheel spin in turns and on slick surfaces – oil on track
- Vehicle Skid Control utilizes wheel rotation sensors, Anti-lock Braking System [ABS], and fuel supply.
- 4-ETS (4 Wheel Electronic Traction System)
  - Provides the effect of locking the front, center, and rear differentials [Full time 4WD system]
  - Uses individual wheel rotation sensors in conjunction with individually braking slipping wheels [and often limits fuel supply] thereby transferring [reduced] power to wheels with traction until the wheels without traction regain traction.
    - Heat build up limits time system can be used – fail safe
    - Tire pressure with respect to tire OD influences system performance
  - 4-ETC continually balances the torque split to direct power to the wheel(s) with traction

Computerized Traction Control cont.

ETC Applications

- Hill Descent Control
  - Developed by Bosch for Land Rover
  - Allows smooth and controlled decent in rough terrain without the driver needing to touch the brake pedal [or accelerator pedal]
- Driver activated and deactivated
- Incorporates wheel rotation sensors, ABS, and fuel supply – engine rpm is reduced and controlled.
- Also utilizes brake fluid pump, pressure reservoir
- Can build up heat so has a fail safe and will shut itself down to prevent component failure

Computerized Traction Control cont.

Electronic Stability Control

- Stability control is more sophisticated than “Traction Control” in that additional sensors are utilized.
- Lateral force sensor, gyroscope, steering angle sensor
- More sophisticated software is also utilized to control the additional hardware in conjunction with the ETC hardware.

Computerized Traction Control cont.

- Usually installed by the manufacturer
- Requires very little driver input
- Reliant on a properly functioning computer and sensors
- Enhances occupant safety
- Stealth partner enabling one to get where one otherwise might not have been able to
- Rule of thumb is to keep steady rpm

Mechanical Traction Control

- All traction control aids have mechanical components
- With ETC, a computer controls the traction system
- Mechanically controlled traction devices are not controlled by a computer.

Mechanical Traction Control cont.

What is a differential?

- When a vehicle turns a corner, the outside wheel must travel further than the inside wheel
- Because the wheels are connected, the outside wheel must travel faster than the inside wheel
- The different speeds that the wheels must travel needs to be permitted.
- A differential allows one wheel on an axle to turn faster than the other wheel on the same axle.

Mechanical Traction Control cont.

The parts of a differential

- Pinion
- Ring
- Side gears
- Pinion gears
- Bearings
- Seals
- Shims and/crush sleeves
- Carrier

Mechanical Traction Control cont.

How does a differential work?

An open differential needs to do three things:

- Balance engine power [torque] between the left and right wheels.
- Serve as a final gear reduction slowing rotational speed of the transmission before the power hits the wheels
- Allow the wheels to turn at different speeds

See http://auto.howstuffworks.com/differential2.htm

Gearing and Tire Size

- Stock
  - 1st gear is 3.8:1
  - Transfer Case reduction is 2.7:1
  - Differential Ratio is 4.1:1
    - Pinion gear turns 4.1 times for the ring gear to turn once
    - 5.38:1 is a low gear ratio while 3.31:1 would be a high gear ratio
    - The higher the number the lower the ratio
  - Tire size is 245/75 R16 [31” tire]
  - Final Drive Ratio in low range
    - = 3.8 x 2.7 x 4.1 = 42:1 Crawl Ratio
- Lift and install 35” tires
  - Without changing diff ratio – what will happen to the rpm at the same speed?
    - Reduce rpm at same speed by 4/31 = 13%
  - What should the new diff ratio be?
    - 4:1 plus 13% results in 4.63. So go to 4.56 or 4.88
  - What is the effective gear ratio with 35” tires
    - 4.1:1 effectively is reduced by 13% to become 3.57:1

Calculation

Simplest form is cross multiplication

	Stock	Lifted
Tire	31	35
Diff	4.1	=(4.1X35)/31 = 4.633

Traction principles

- An open differential allows the wheels on the axle to turn at different speeds
- Myth: If one wheel has no traction, the other wheel will not get any torque. Not strictly true
- The function of an open differential is to balance torque between the left and right wheels.
- Even with one wheel spinning in the air, torque is required to overcome friction and cause the wheel to spin.
- The equivalent amount of torque is applied to the other wheel although that amount of torque may be insufficient to move the vehicle giving the appearance that it gets no torque.

Traction principles cont.

- Myth: when a wheel starts spinning, stepping on the gas more will get me out.
- Not always true. Although increasing speed of the spinning wheel does require more torque, it is seldom enough to move the vehicle.
- A wheel spinning faster is also less able to get a grip on a loose surface that a slower spinning tire lost traction on.
- Instead, what spinning the wheel faster may do is grenade your pinion gears and side gears as the do not run on bearings, can thus over heat and seize.

Traction principles cont.

- The result is that not enough of the engines torque will be directed to the wheel with traction = stuck ☹
- ETC uses ABS braking on the spinning wheel to increase the amount of torque required to turn the spinning wheel.
- This allows the open differential to balance the increased torque and transfer more torque to the wheel with traction and move the vehicle.
- Skilled drivers can do the same with the pedal brake [or emergency brake for rear axle]
- A differential lock connects [locks] the axle side shafts together thereby forcing both wheels to turn together at the same speed.
- This allows the wheel with traction to now turn and move the vehicle – unstuck. ☺

Types of Mechanical Traction Aids

- Differential locks
  - Automatic
  - Switchable / Selectable / On command
    - Electric: ELocker
    - Air: ARB Locker
    - Cable: OX Locker
    - Hydraulic: MB G Class
- Limited Slip : preset amount of torque
  - Torque Sensitive
  - Speed Sensitive
- Spool

How does a differential lock work?

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Automatic Differential Locks

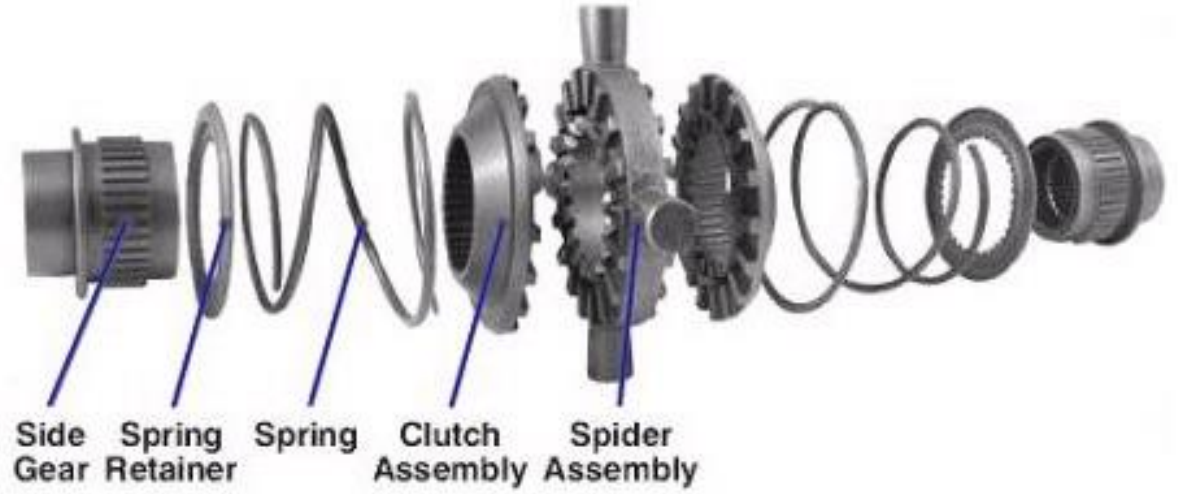
- Automatic differential locks are those that are not switchable or selectable.
- As long as the vehicle is operated in a straight forward or reverse direction over a smooth surface, the driven clutch assemblies remain locked to the spider assembly.
- The differential locks the axle shafts together. This means both wheels turn at the same speed. If one wheel loses traction or leaves the ground, the opposite wheel, which still has traction, continues to drive the vehicle until traction is regained by both wheels. There can be no one-wheel spinout

Automatic Differential Locks cont.

- When the vehicle turns a corner the outside wheel must travel a greater distance and therefore faster than the inside wheel.
- The differential lock automatically allows for the necessary difference in wheel speed.
- When cornering, the inside driven clutch remains completely engaged with the spider and continues to drive the vehicle with the inside wheel.
- The outside driven clutch automatically disengages from the spider, allowing the outer wheel to turn freely and allowing it to turn faster than the inside wheel
- When the vehicle completes the corner, the outside driven clutch automatically reengages the spider, as both wheels again travel at the same speed.

Automatic Differential Locks cont.

Detroit Locker [and Lock-Right]



Automatic Differential Locks cont.

- The disadvantage of the automatic lockers is the influence on the handling characteristics of the vehicle when the locker engages accelerating out of a corner or disengages going into a corner.
- Similar handling anomalies result on slippery surfaces
- The engagement and disengagement of the automatic locker in the rear axle tends to force the rear of the vehicle sideways.
- The engagement and disengagement of an automatic locker in the front axle can severely impact steering response when cornering – “torque steer”.
- Similar handling characteristics occur with a selectable locker engaged.

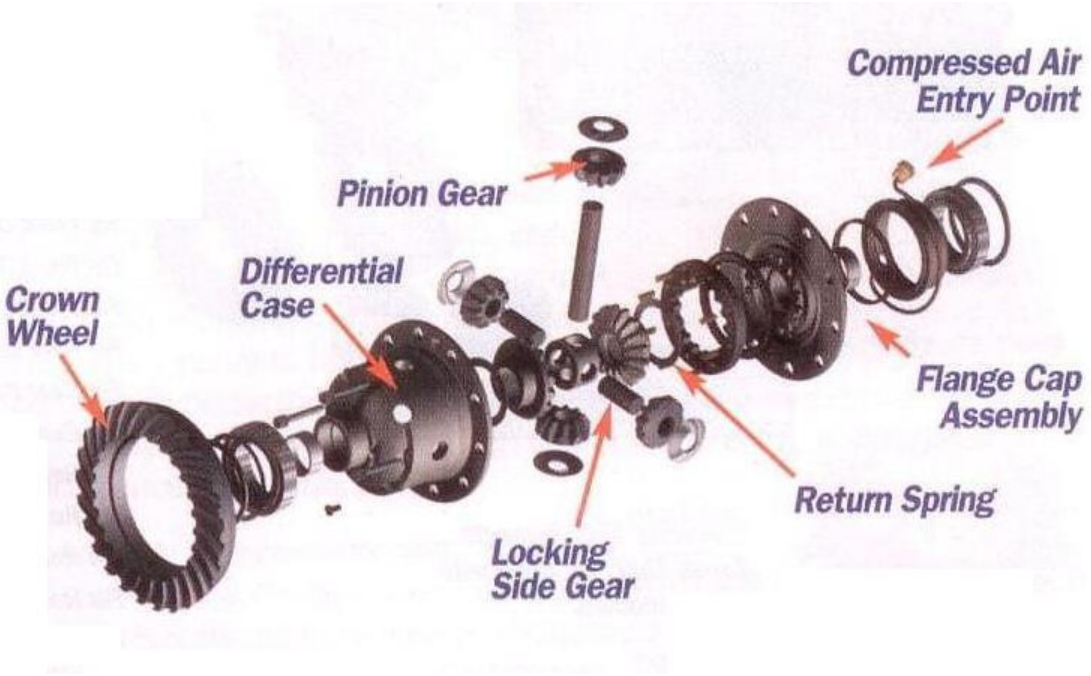
Switchable / Selectable lockers

- The two main differences between switchable / selectable lockers and automatic lockers are:
  - The driver can choose when to engage and disengage
  - Once engaged, they stay engaged until the driver disengages them.

Switchable / Selectable lockers cont.

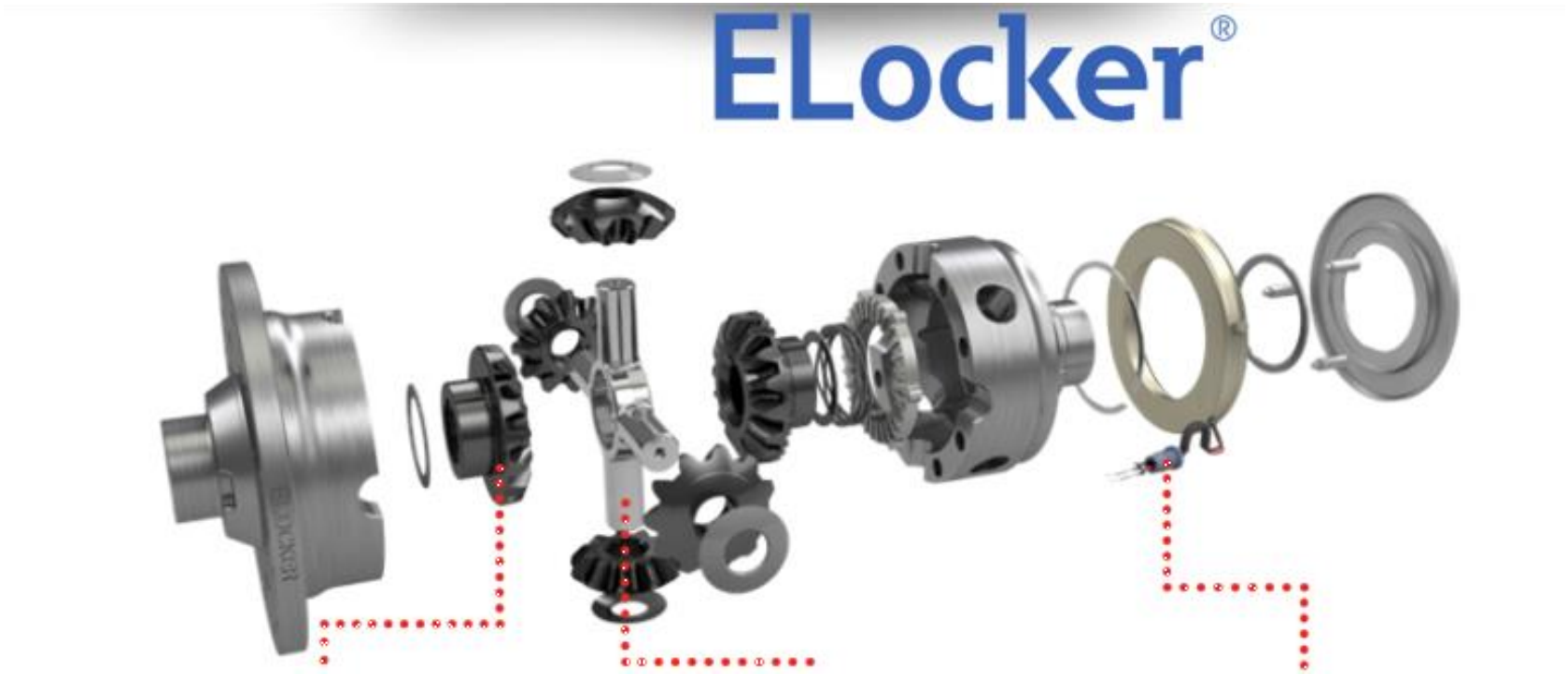
- Selectable lockers when disengaged do not affect vehicle handling at all.
- Selectable lockers are generally more complex and more expensive than automatic lockers.
- Selectable lockers have more components and failure of these components, that could be outside the differential, could prevent activating the locker.
- Complex and expensive installation

Switchable / Selectable lockers cont.



Switchable / Selectable lockers cont.

Eaton Performance ELocker



Limited Slip Differentials

- As the name implies “limited slip” differential limits the amount of “slip” between the axle side shafts
- As we learned an “open” differential serves to:
    - Balance engine power [torque] between the left and right wheels.
    - Allow the wheels to turn at different speeds

Limited Slip Differentials cont.

- We also learned that:
  - with one wheel spinning in the air, torque is required to overcome friction and cause the wheel to spin, and
  - The equivalent amount of torque is applied to the other wheel although that amount of torque may be insufficient to move the vehicle giving the appearance that it gets no torque.
- A limited slip differential fundamentally adds a lot more friction and thereby creates more torque to be applied to the axle side shafts and this allows the wheel with traction to turn and move the vehicle

Limited Slip Differentials cont.

- The wheel with traction will turn slower than the wheel without traction, hence “limited slip” or rather allowing some slip compared with no slip – bias ratio
- In some applications the bias ratio can be adjusted with clutches, springs, friction lubricants etc.
- NoSlip was actually the name given to the Detroit Locker in 1941 when it was first introduced.

Limited Slip Differentials cont.

Limited slip differentials fall into two main categories:

- Torque sensitive
  - Respond to drive shaft torque
- Speed sensitive
  - Respond to wheel speed

Torque based LSD

- Various methods are used to “add friction” to the differential. These include:
  - Clutch plates and special oils
  - Gear based helical or worm
    - Torsen, Quaife ATB, Truetrack
  - Cone based
- Fundamentally they all work through the increased friction generated by the interaction of mechanical parts.
- This increased friction allows for the application of increased torque to the wheel with traction.

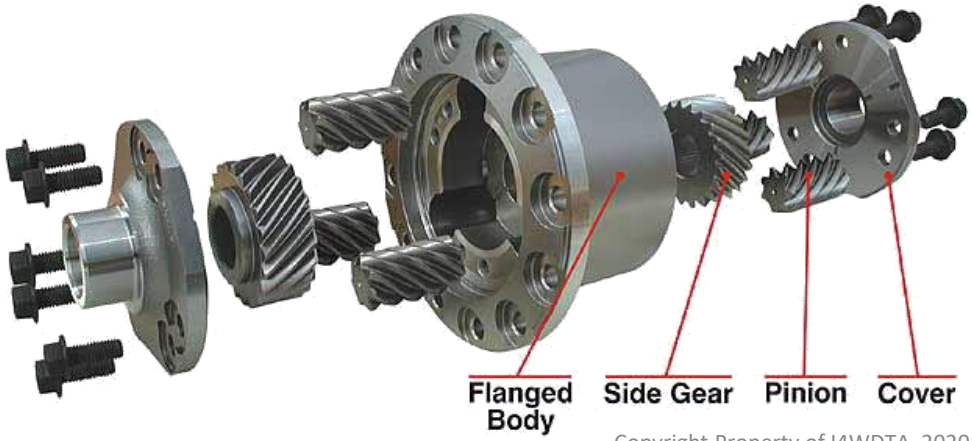
Clutch LSD

ZF Friedrichshafen AG

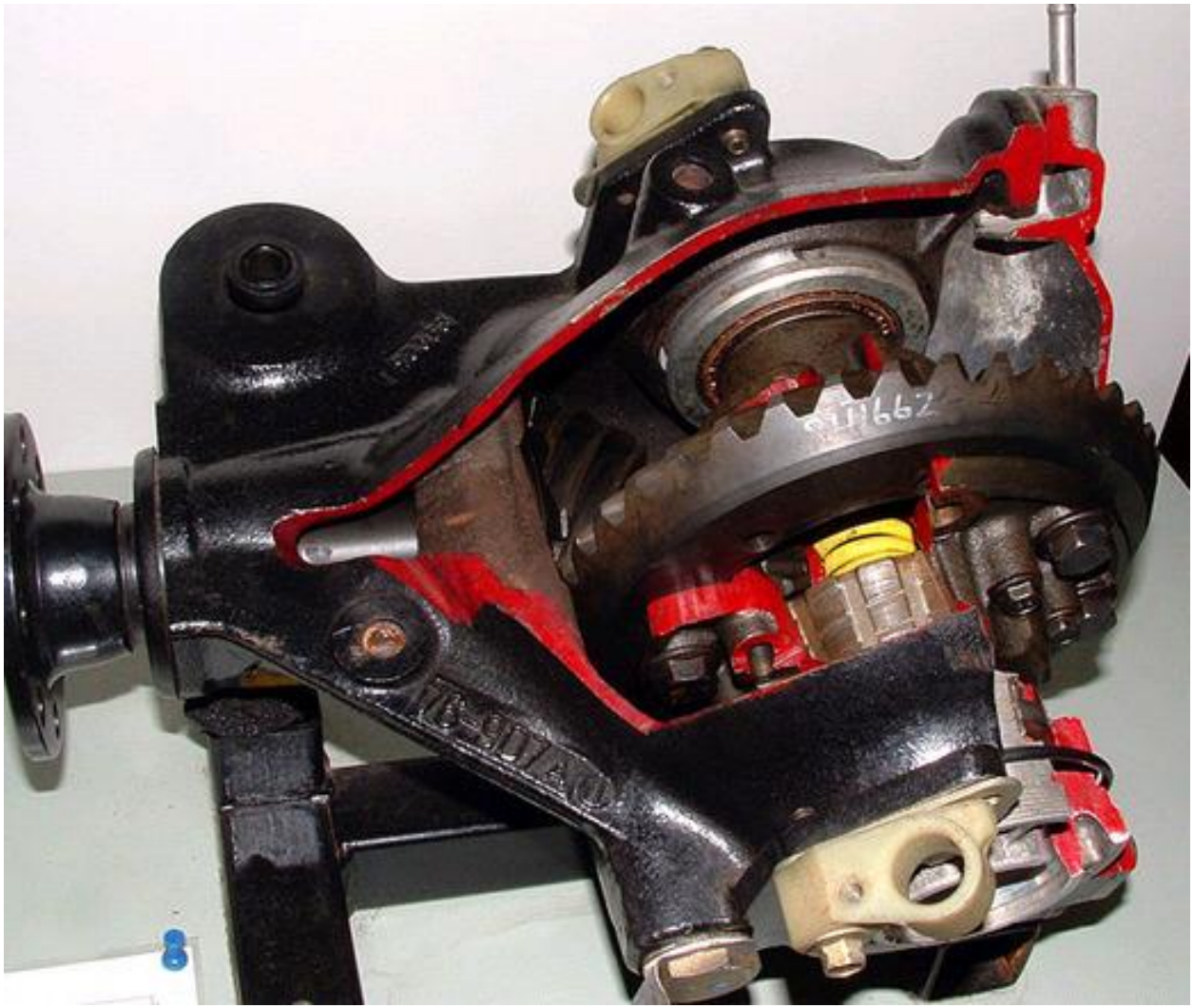
Gear LSD

Torsen

True Trac



Cone LSD



Torque based LSD cont.

- They do not negatively affect vehicle handling because the wheels can still turn at different speeds.
- They tend to wear out – especially the clutch plate types
- The gear types last longer
- They are not as suited to hard off-highway work and can cause the differential to overheat.

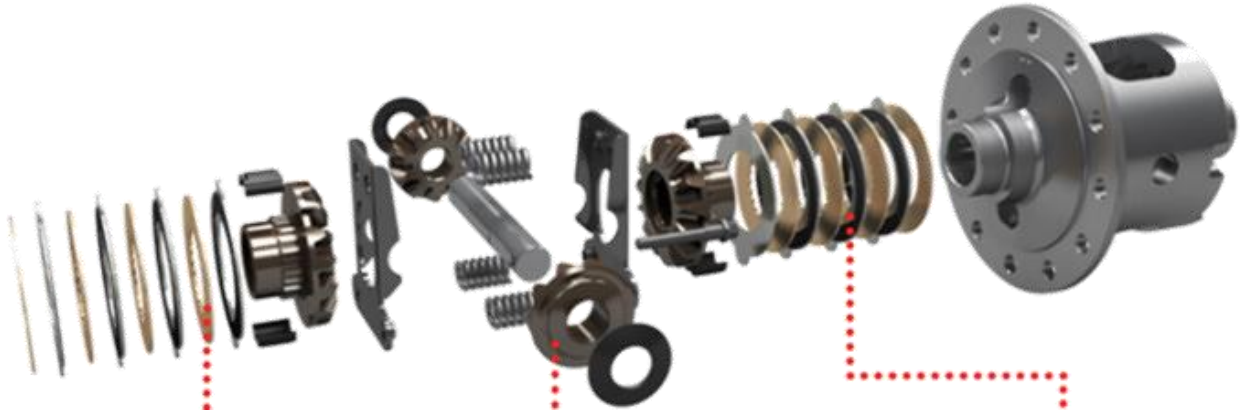
Speed Sensitive LSD

Speed sensitive LSD include:

- Viscous coupling
  - Uses hydrodynamic friction from fluids with high viscosity.
  - Chamber filled with silicone based oils.
  - Inside chamber coupled to one axle side shaft
  - Outside of chamber coupled to other axle side shaft
  - Chamber contains perforated plates/discs.
  - ½ Perforated plates are attached to inside chamber, the other ½ to the outside chamber in an alternating pattern
  - Less efficient and can “loose power” much like an automatic transmission

Speed Sensitive LSD cont.

- Speed sensitive LSD include:
  - Gerotor Pump
    - Uses gerotor [hydraulic] pump to compress a clutch pack
- Notes:
  - Positraction is a LSD introduced by Chevrolet in 1956.



Other names for LSD's

Other factory names for LSDs include:

- Alfa Romeo: Q2
- American Motors: Twin-Grip
- Buick: Positive Traction
- Chevrolet/GMC trucks (after 1973): Gov-Lock
- Ferrari: E-Diff
- Fiat: Viscodrive
- Ford: Equa-Lock and Traction-Lok
- International: Trak-Lok or Powr-Lok
- Jeep: Trac-Lok (clutch-type mechanical), Tru-Lok (gear-type mechanical), and Vari-Lok (gerotor pump)
- Mopar: Sure Grip
- Oldsmobile: Anti-Spin
- Pontiac: Safe-T-Track
- Saab: Saab XWD eLSD
- Studebaker-Packard Corporation: Twin Traction
- TVR: Hydratrak

See http://en.wikipedia.org/wiki/Limited_slip_differential#Speed-sensitive

Spool

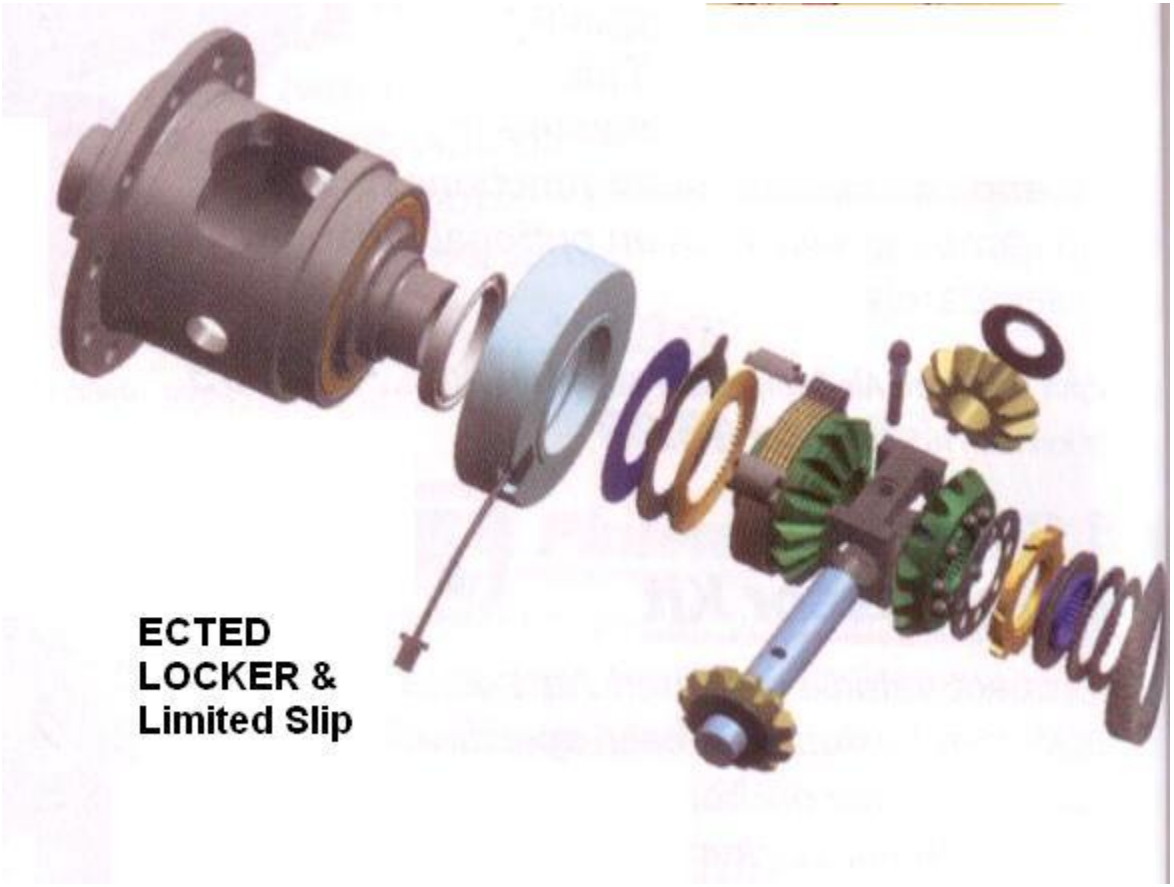
- A spool rear end allows no differential rotation.
- It consists of a pinion & ring gear only with a solid center
- This makes the axle acts as one piece.
- A mini-spool is similar
- “Home made Spool” can be made by welding-solid a standard open differential. The spider gears are welded to the side gears.

Spool

Delivers handling characteristics similar to an engaged selectable locker all the time.

Interesting Traction Aids

Electronically Controlled Traction Enhancing Differential ECTED



What I use

- I prefer the switchable / selectable lockers
- Have ARB's on my Toyota Pick-up
- ARB on my 2003 Rubicon rear Pro Rock 60
- Have OEM on my Rubicon front 44
  - modified to engage independently
- Have OEM on my Landcruiser
  - Modified rear to be cable operated
  - Able to engage independently
- Have Lock-Right in my 1952 M38

Summary

- Computer Controlled
  - Electronic Traction Control
- Mechanically Controlled
  - Differential lockers
    - Automatic
    - Switchable
      - Electric
      - Air
      - Mechanical
  - Limited slip differentials
    - Torque sensitive
    - Speed sensitive
- Spool