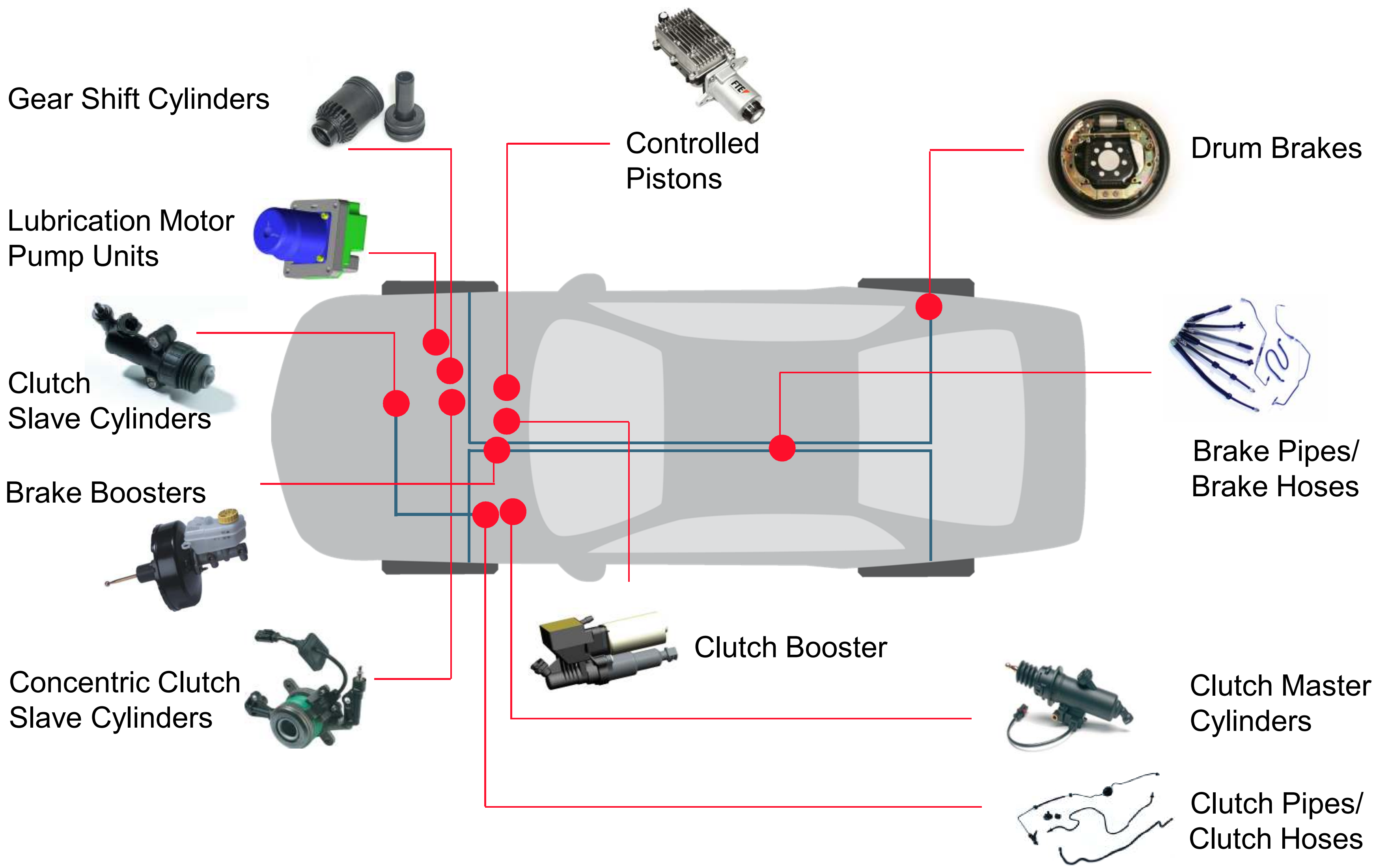
FTE Hydraulic Clutch Actuation Basics

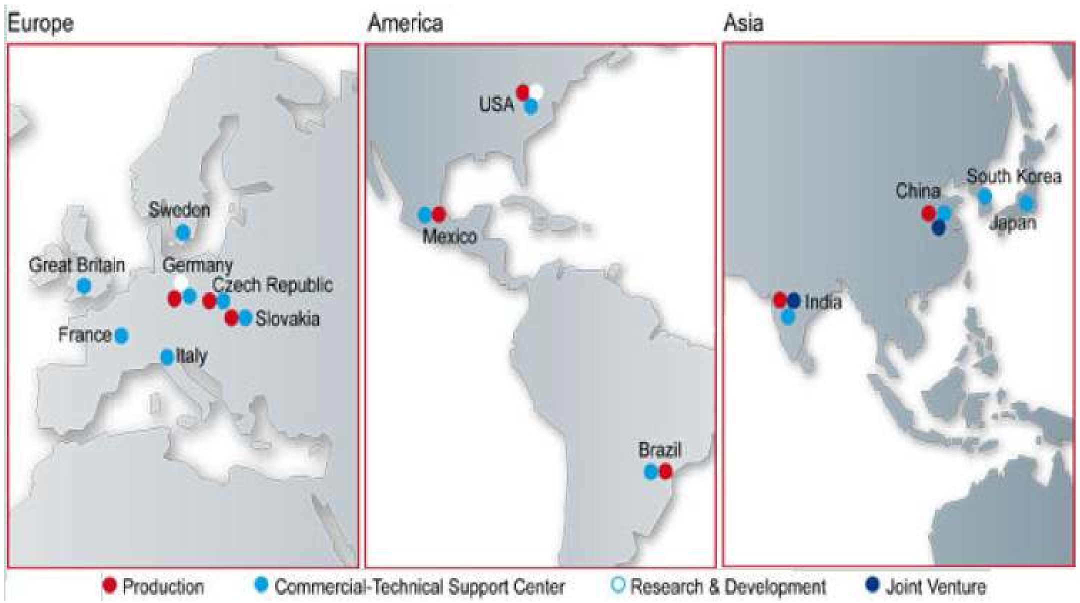
Vehicle Products - FTE



World Presence – FTE Global

FTE originally stood for Fahrzeug Technick Ebern.

Translated to English, FTE means Vehicle Technology Ebern.



FTE Manufacturing Centers

GERMANY:
Ebern
Fischbach
Mühlhausen

SLOVAKIA
CZECHIA
CHINA

USA
MEXICO
BRASIL

Overview - FTE Brazil Plant

Maua , São Paulo

- **FTE Industria e Comercio Ltd.**
- **Brazil**

• 2011

São Bernardo do Campo, São Paulo

Overview - FTE Brazil Plant

History

- **1999** **-** Start of production
  - Location – Gravataí – Rio Grande do Sul
  - Employees: direct – 6
    indirect – 4
- **2003** - New location in São Bernardo do Campo – S. Paulo
  - Employees: direct – 12
    indirect – 4
- **2005** - QSB certification from GMB
- **2006** - TS16949 certification
- **2007** - ISO 14001 certification
  - Indicated to GMB as “Supplier Merit Awards”
- **2008** **-** Received from GMB the “Supplier Merit Awards”
- **2009** - Relocation to new facility
- **2010** **- New Organization Structure**
- **2011** **- New programs: total ~ 100 new employees + new Plant 8000 sqm**

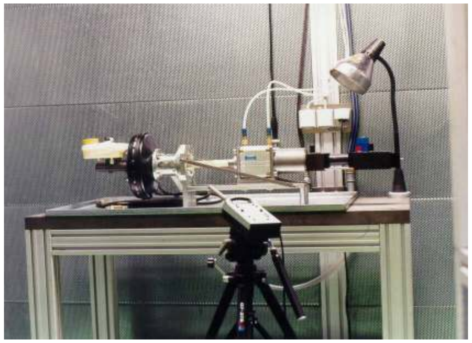
Validation to customer specification and development – FTE USA

Inhouse Testing Capabilites
FTE USA Technical Center

- **DURABILITY TEST STANDS (DYNAMIC RIG)**
  - **FUNCTION**
  - **VIBRATION/TEMPERATURE**
  - **CLIMATE/DUST**
- **CLIMATE CHAMBERS**
- **CORROSION CHAMBER (Salt Spray)**
- **BURST CHAMBER**
- **VIBRATION (Shaker)**
- **VEHICLE SOUND ROOM**
- **VEHICLE BUCKS/MULES**
  - **FUNCTION**
  - **TEMPERATURE**
- **VEHICLE GARAGE**
  - **INSTRUMENTION CAPABILITIES**
  - **CONVERSION/RETROFIT**

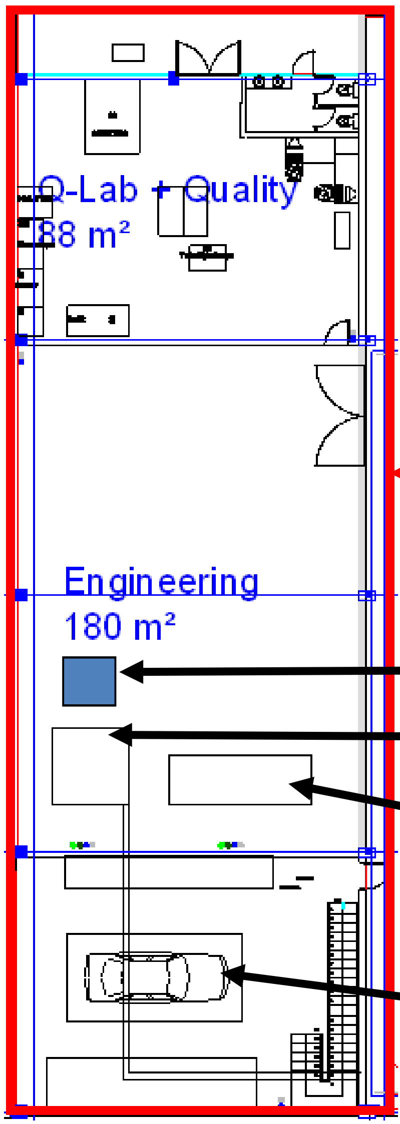
Inhouse Testing Capabilites
FTE EBERN Technical Center

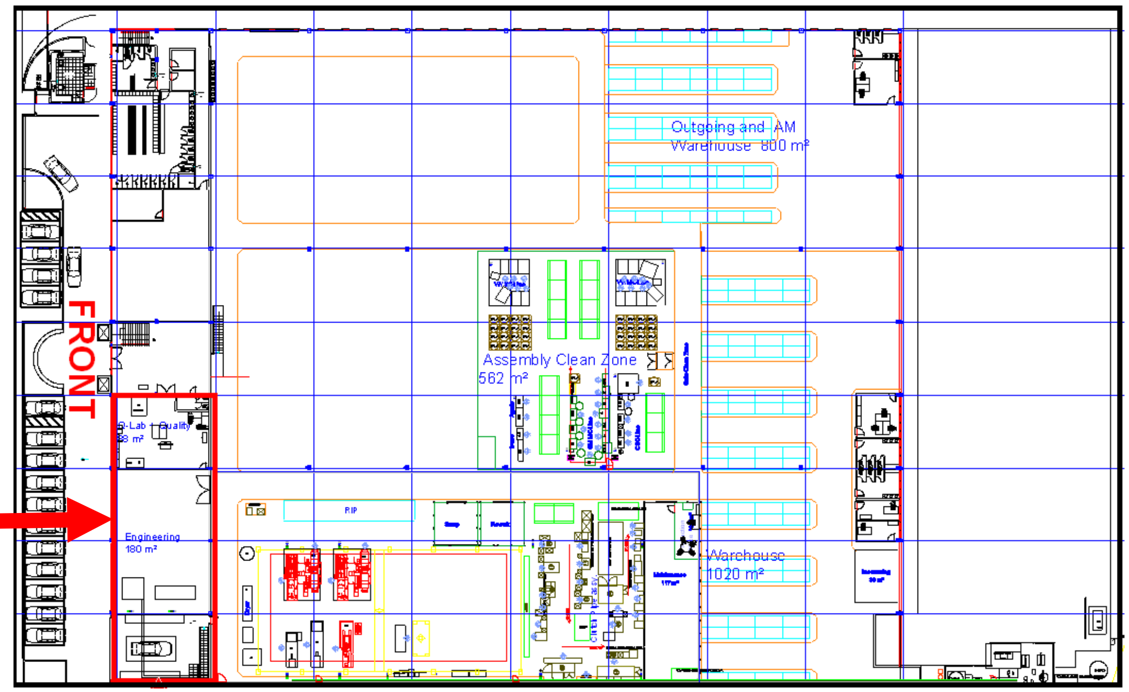
- FUNCTION MEASURING TEST STANDS
- DURABILITY TEST STANDS
  - FUNCTION
  - VIBRATION/TEMPERATURE
  - CLIMATE/DUST
- LABRATORIES
  - MATERIAL
  - RUBBER
  - MEASUREMENT
- VEHICLE TEST STANDS
  - FUNCTION
  - TEMPERATURE
- VEHICLE GARAGE
  - INSTRUMENTION CAPABILITIES
  - CONVERSION/RETROFIT
- TEST TRACK



Maua R&D Department – Engineering Department Layout





Burst chamber – 2014

Thermal Chamber with actuation station. 2013

Efficiency Factor Test Bench 2012
Small Chamber 2012

Hoist 2012

Maua R&D Department – Current Resources

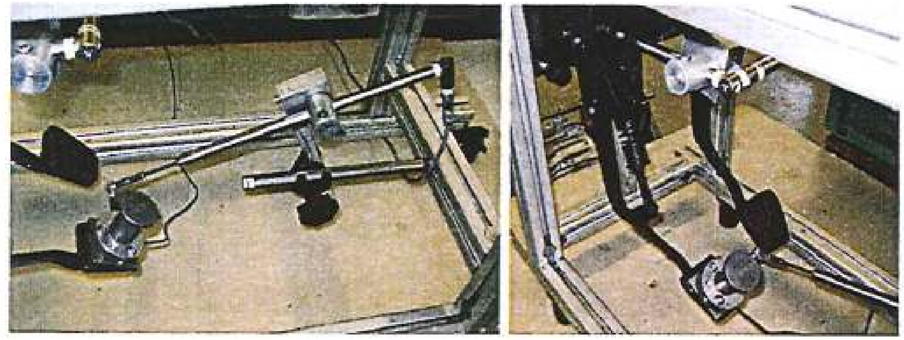
Pedal Curve Equipment: Spring Pot, Load Cell, & Laptop

What is the device designed to accomplish.

Ability to measure loads and travel in vehicle.

Address what customer need:

Measure pedal response in vehicle at customer location



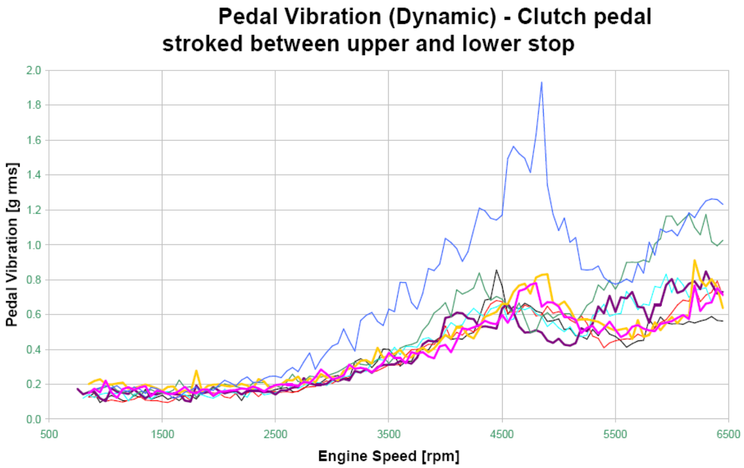
Vibration Equipment: Accelerometer, string pot (travel) & lap top w/ signal conditioner

What is the device designed to accomplish.

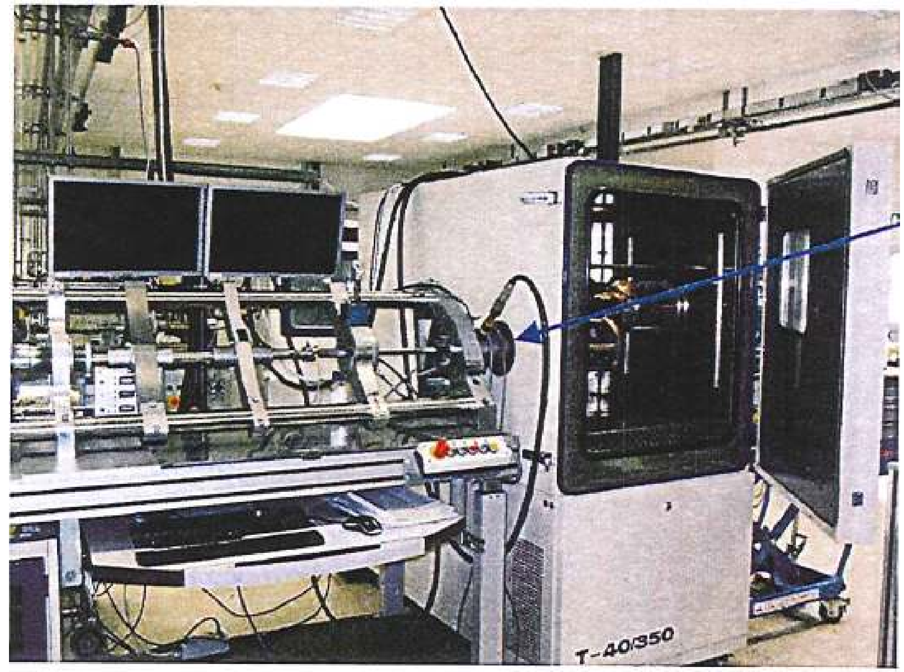
Ability to measure pedal vibration transmitted from the engine through the customer actuation system felt by the end customer.

Address what customer need:

Measure and quantify situation and solutions at customer location.



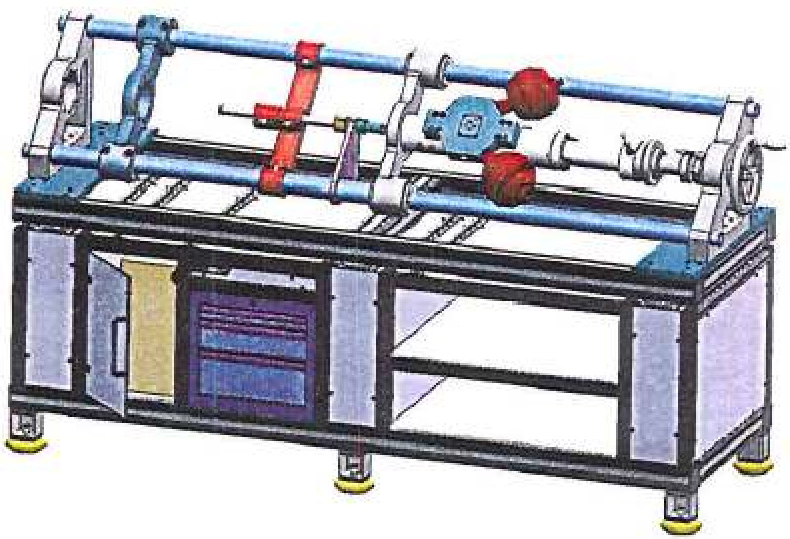
Efficiency Factor Test Bench



What is the device designed to accomplish.

Measure load, pressure, and travel at different controlled rates of speed and temperature with master, pipe, and slave cylinder.

Availability : 2012



Address what customer need:

Ability to react quickly to customer need and address system design and analysis with the customer during development process.

Ability to perform development studies without instrumentation into the vehicle.

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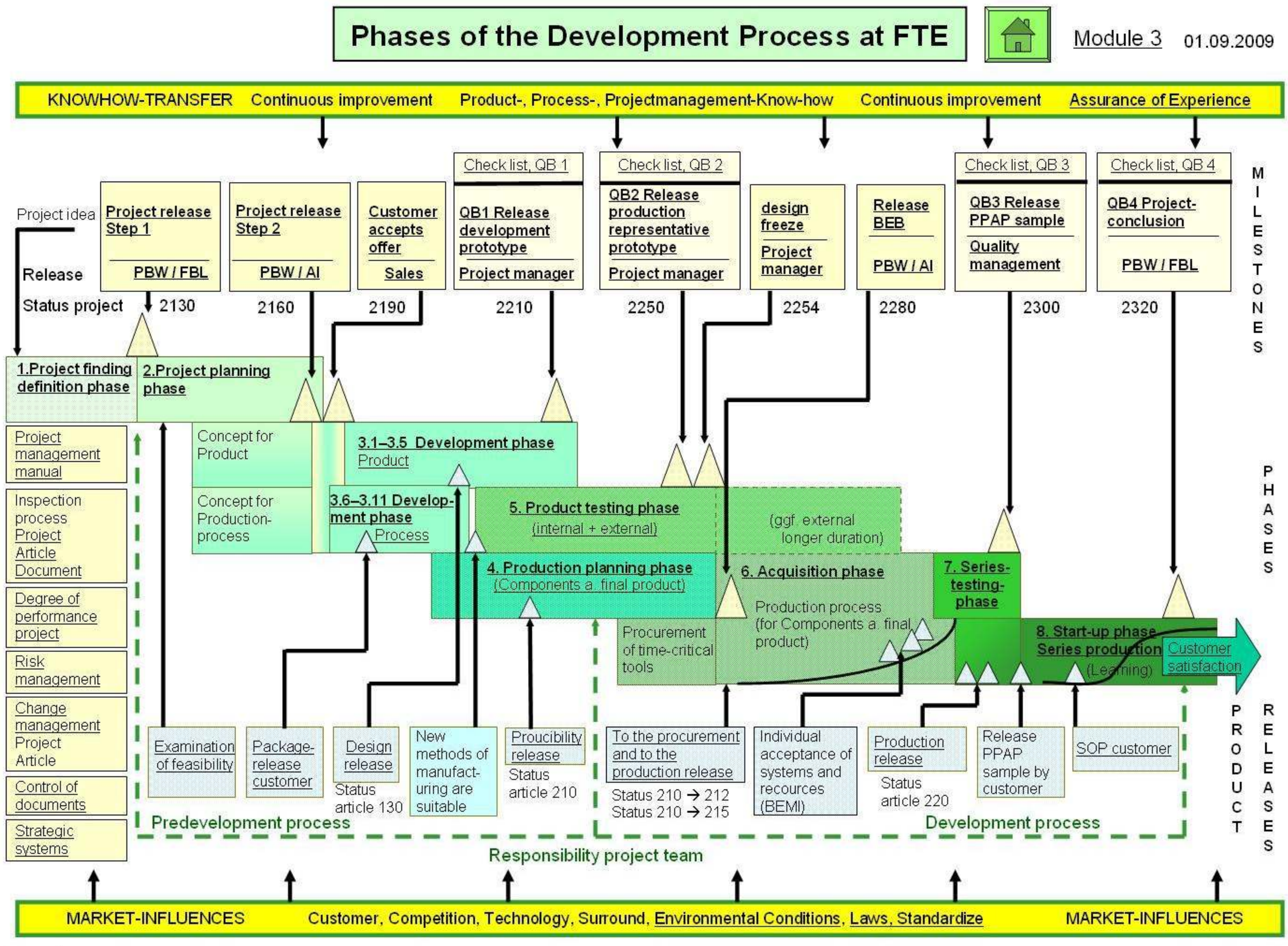
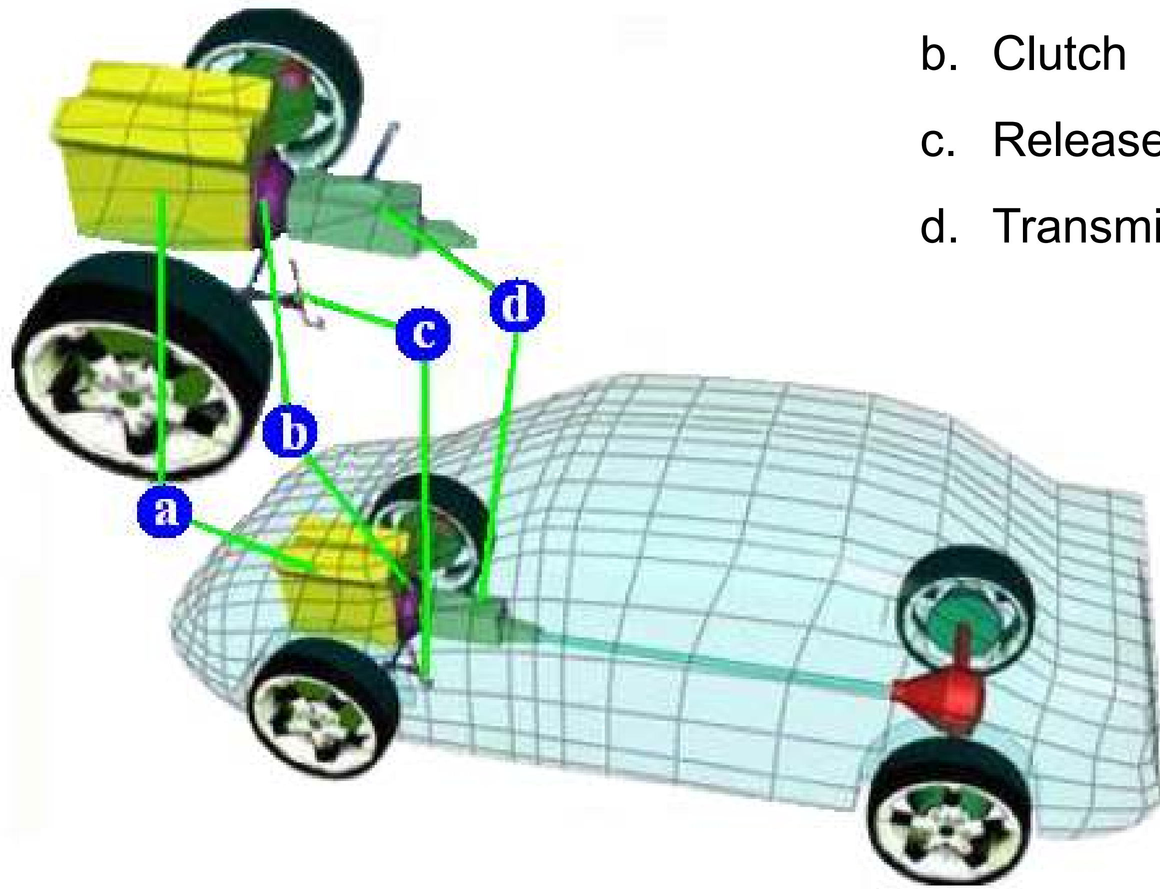
PDM – FTE Global Standard Management System





a. Engine
b. Clutch
c. Release System
d. Transmission

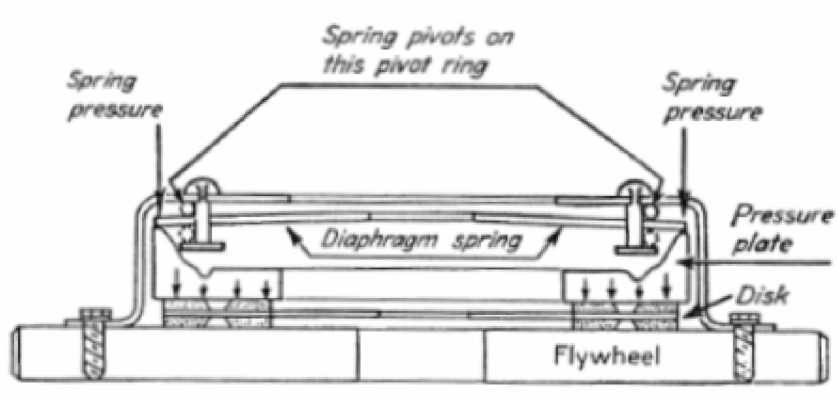
Overview

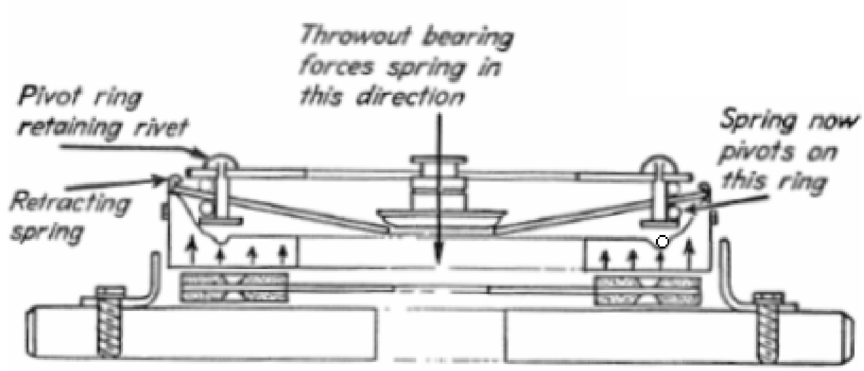
A typical hydraulic actuation system consists of a master cylinder attached to the clutch pedal, a suitable clutch tube and a slave cylinder used to control the clutch. The function of the automotive clutch is to provide an interruptible coupling between the engine and manual transmission. This is required due to the torque characteristics of the internal-combustion engine, which requires the engine be started with no load. Modern manual transmissions also require an interruption of input torque in order to properly accomplish the task. Coupling the engine torque to the transmission, particularly from a standing start, is a much more complex task. Engaging the clutch from a standstill requires the coordination and modulation of engine torque with the throttle pedal, torque transmitted through the clutch with the clutch pedal, and vehicle speed.

The components of the total system must be considered as a whole or integrated. A change in one item of the system has a considerable effect on the remaining portion.

Clutch Function

The functioning of a clutch is determined by the required clamp load. The clamp load is determined by engine torque. The clamp load is the load or squeeze put on the disk by the clutch pressure plate acting against the flywheel with the disk compressed between the two. By varying the clamp load on the disk from a high load (clutch fully engaged) to essentially zero (clutch released), the power path of the engine driving the drive wheel can be regulated to match the conditions required to operate the vehicle. This is accomplished with an actuation system that connects the clutch pedal to the clutch. When the clutch is fully engaged the disk is compressed between the clutch pressure plate and flywheel. When the clutch is released, a small gap is produced between the disk and flywheel so that the disk is no longer being driven at the same speed as the engine/flywheel. The gap at the disk is what is controlled by the clutch actuation system.

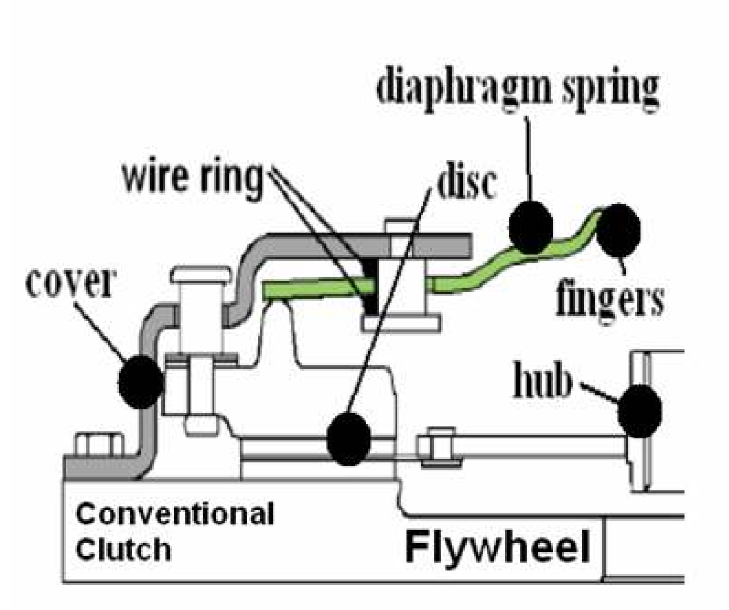




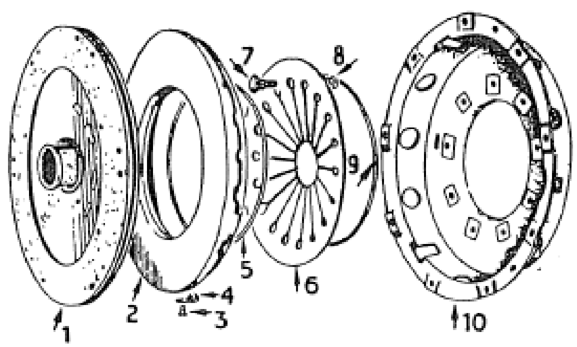
Clutch Function - FTE Hydraulic Clutch Actuation Basics

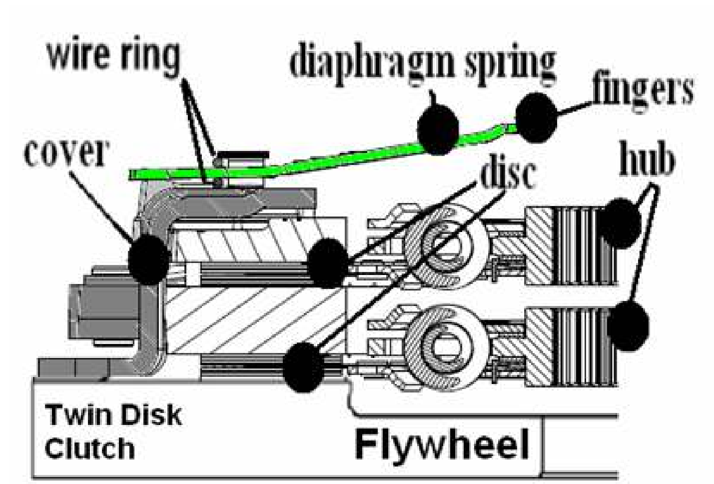
FTE automotive

Diaphragm clutches come in many different variations depending on the manufacture but are all the same basic design, including multi-disc clutches. Multi-disc clutches (i.e twin disk clutch) ensure dynamic performance in areas where single-disc clutches reach their limits. Multiplying the number of friction surfaces increases torque and thermal capacity, and therefore best use is made of the installation volume.



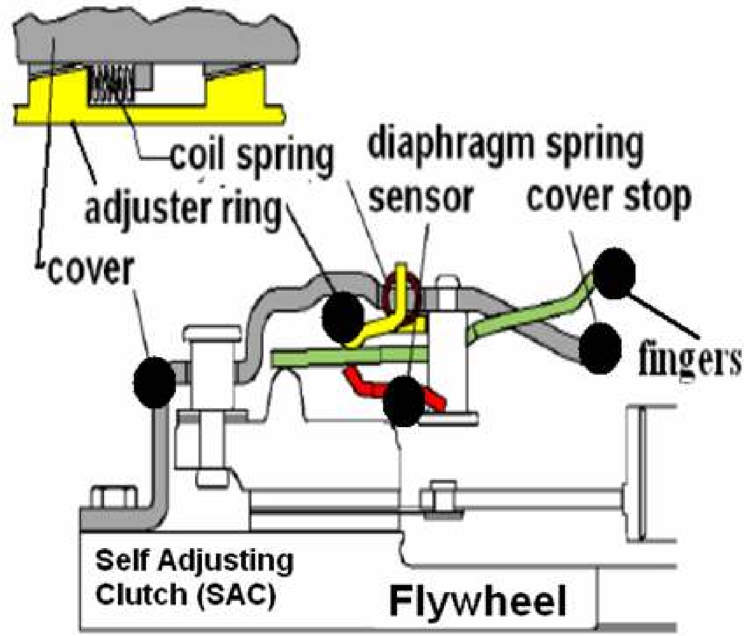
1. Driven Plate
2. Pressure Plate
3. Retracting Spring Retaining Bolt
4. Pressure Plate Retracting Spring
5. Inner Pivot Ring
6. Diaphram Spring
7. Spring Retainer Bolt
8. Spring Retainer Bolt Nut
9. Outer Pivot Ring
10. Clutch Cover

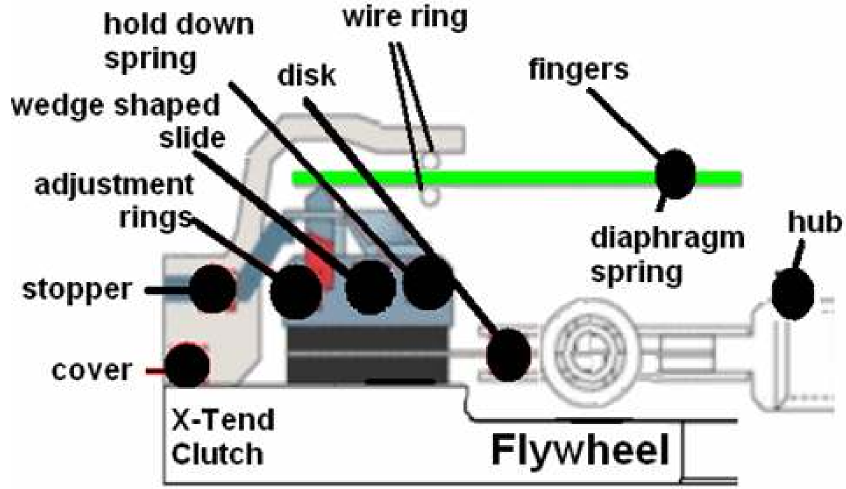




Clutch Function - FTE Hydraulic Clutch Actuation Basics

A more recent development of the **diaphragm clutch** basic design is the **S**elf-**A**djusting **C**lutch. This clutch has a mechanism that compensates for disk wear and by balancing forces within the clutch design by a secondary spring controls the amount of load change felt at the clutch pedal as the clutch life progresses from new to full worn. This clutch is more complicated than the standard diaphragm clutch. The **XTend** clutch is also another example of a self compensating clutch. This is achieved by means of distance rings inserted between the diaphragm springs and the pressure plate. As wear on the clutch facings increases, they automatically turn just far enough to let their increase in height compensate for the decrease in thickness of the facings. The diaphragm spring thus always remains in the same position and the actuation forces and paths remain constant.



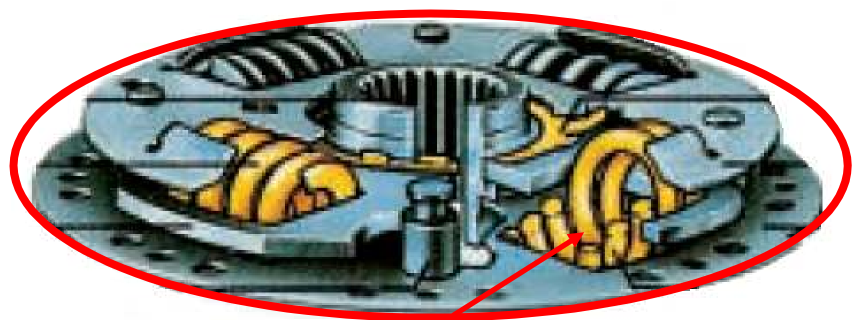


The **clutch disk** or driven plate is the part containing friction surfaces that actually transmit the engine torque/rotation to the rest of the driveline. Clutches are sized by the OD of the disk (Example, a 192 mm clutch is a clutch whose disk OD is 192 mm). The disk is constructed with flexibility in mind to allow for feel and drivability of the vehicle. These consist of a cushion spring, a thin wave spring found between the two friction faces, and damper springs seen visually when the disk is viewed from the top or bottom.

Clutch Disk

Cushion Spring

The cushion spring enhances the feel in the clutch pedal allowing an increased modulation zone in the clutch pedal stroke. This allows an operator to better sense the take up of the clutch as it first starts to transmit motion and force. This modulation is important to the drive ability of the vehicle during the transition from rest to motion.



Damper Spring

The damper springs are present to control harshness and rattle sensed in the vehicle as the vehicle is operated. These springs are used to dampen gear rattle to improve the N.V.H. (Noise Vibration and Harshness) of the powertrain. They come in many configurations and constructions.

Principle

An automobile clutch is actuated by the driver pressing the **clutch pedal**, which through its ratio operates the pushrod on the **clutch master cylinder**, this generates fluid flow and then hydraulic pressure which is transferred via a **clutch tube** – to a **slave cylinder** or actuation cylinder. The slave actuates a **lever** of predetermined ratio, which then pushes the **release bearing** against the **clutch**, releasing the clamping mechanism in the cover assembly.
The clutch control system being hydro mechanical in nature (hydraulic and mechanical) works through a series of ratios. These ratios all work to multiply a force of 25 to 35 lbs. (125-175 N) at the driver's foot to control several hundred pounds at the clutch (clamp load).

In designing a hydraulic actuation system for a particular application, we modify these ratios to give the correct effort at the pedal with appropriate pedal travel.

The different ratios talked about above are ratios that mechanically act like levers. The exception to this is the hydraulic ratio. This is the ratio of the area of the slave cylinder divided by the area of the master cylinder.

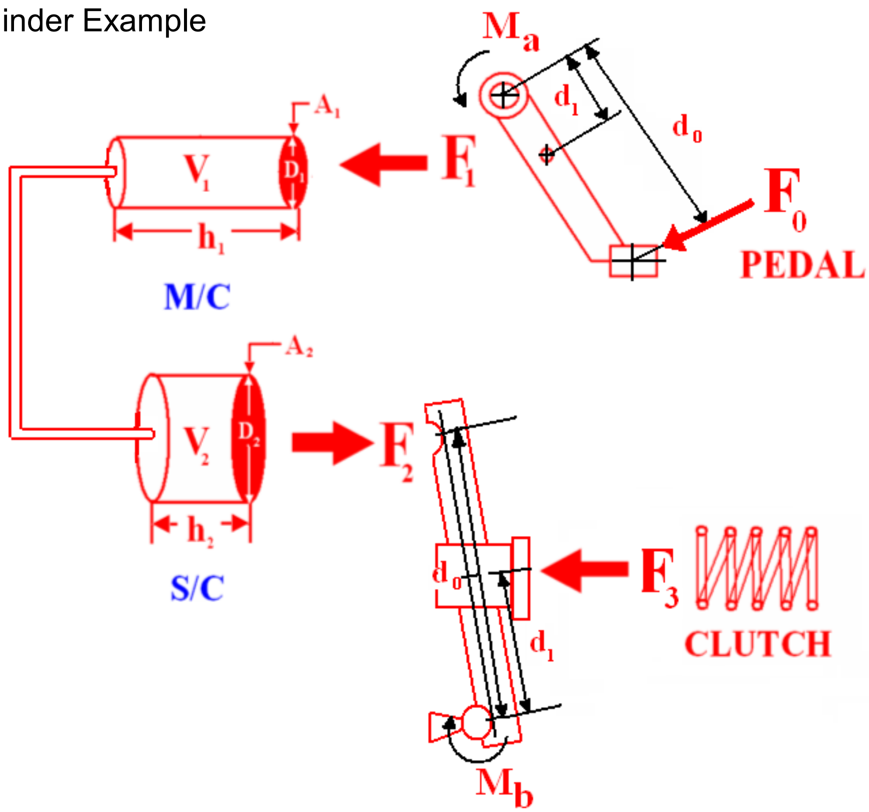
Hydraulic Ratio = $\frac{\text{Area of S/C}}{\text{Area of M/C}}$

Pascals Law

F1/F2=A1/A2=H2/H1

P=F1/A1=F2/A2

External Slave Cylinder Example



For an external system (slave cylinder mounted outside the transmission):

Clutch Ratio – Typically = 5 to 1 (internal to the clutch diaphragm spring)
Release Lever Ratio – Typically = 1 or 2:1 (use 2 to 1)
Hydraulic Ratio – Typically 1.3 to 3.2 to 1 (use 2 to 1)
Pedal Ratio – Typically 4.5 to 7 to 1 (uses 5 to 1)

Multiplying these ratios:

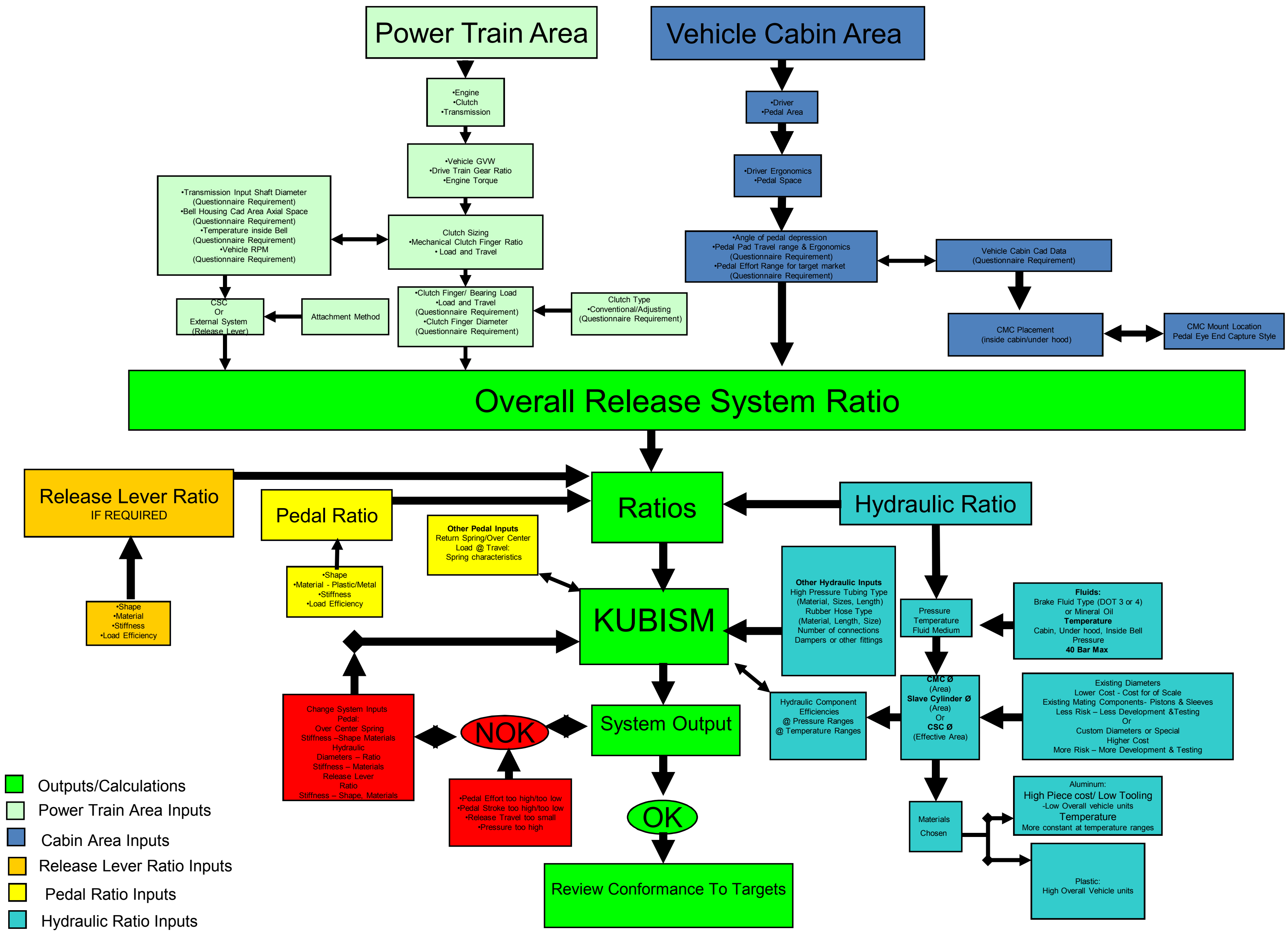
Clutch		Lever		Hydraulic		Pedal	
5	X	2	X	2	x	5	= 100 or 100 to 1

Total ratio is 100 to 1.

The ratios not only multiply the effects of force; they also multiply the effect of dimensional changes within the clutch system.
To illustrate this, if there is a travel change of 0.5mm at the clutch, by multiplying this through the ratios, it could have a 50mm effect on travel at the clutch pedal pad (0.5mm x 100 = 50mm). This is nearly two (2) inches.
When changes like this occur, the actuation system needs to be able to accommodate these changes since it transmits force and motion between the clutch pedal and the clutch.

The release system ratio is defined as the Pedal Ratio X Hydraulic Ratio X Release Lever Ratio (when sc is mounted outside the transmission).

System Calculation Flow Chart- FTE Hydraulic Clutch Actuation Basics



Reserve Defined: (RED)

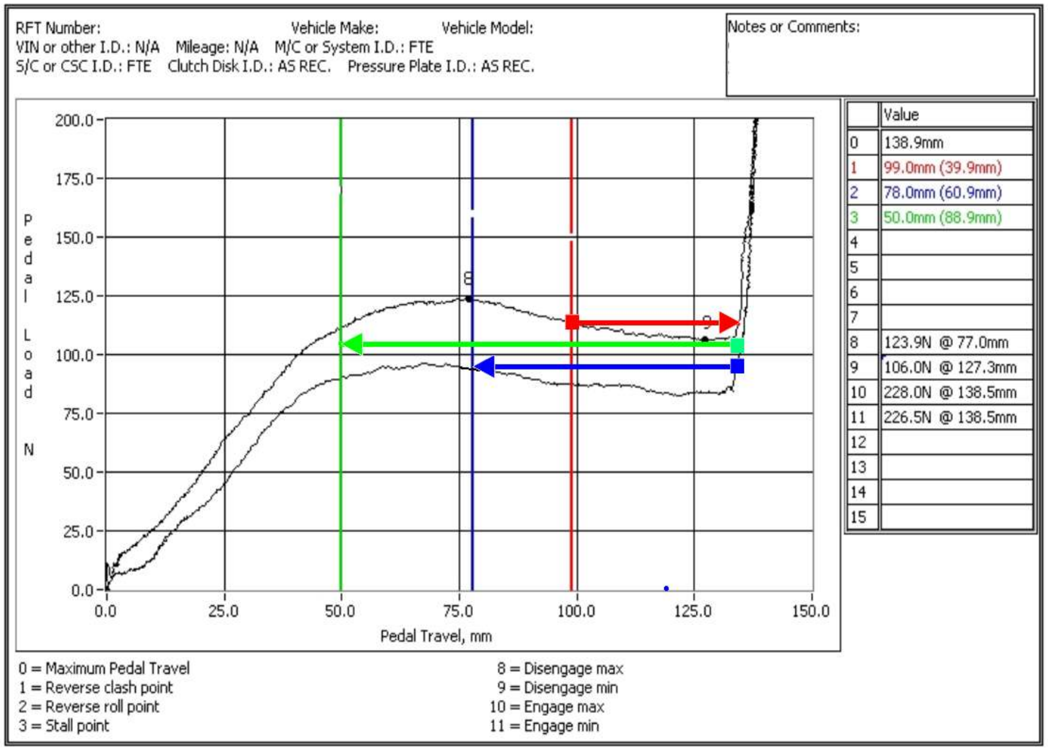
Point on the pedal curve at which the pedal is being depressed and the point on the clutch where there is enough separation "lift off" between the pressure plate and flywheel where the clutch disk is able to spin freely (stop transmitting torque) usually defined by < .5 Nm of drag torque, from this point to the end of pedal travel.

Engagement (or roll) Defined (BLUE)

Point on the pedal curve at which the pedal is being released from the full travel position to where the clutch pressure plate is contacting the clutch disk and flywheel allowing enough clamp load and torque transfer required to move or "roll" the vehicle.

Stall Defined (GREEN)

Point on the pedal curve at which the pedal is being released from the full travel position to where the clutch pressure plate is contacting the clutch disk and flywheel allowing enough clamp load while the brake is depressed to stall the vehicle.



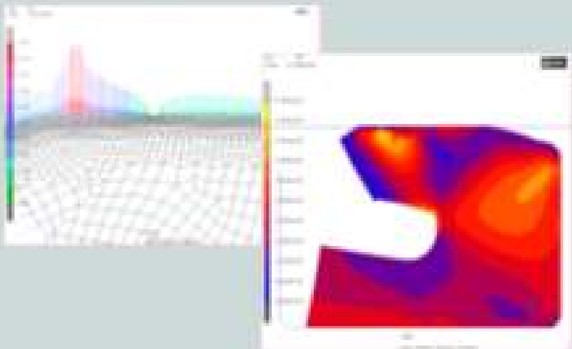
Other important points on the pedal curve:

- #8 Peak Pedal load at given travel.
- #9 Valley Pedal load at given travel.
- Hysteresis: Load difference between apply and return.

Technology-Competence

- **Full service supplier** from the first concept to series production
- **Over 30 years experience** in developing and manufacturing of clutch and brake hydraulics.
- **Rubber production** with own development from elastomer-raw material to production of sealing elements and hoses
- In house **machining, turning**, and **molding**.
- First producer of **ABS for motorcycles**
- Own **sensor development department.**

Design



Seals are designed specially for each application with regards to:

- *Temperature range*
- *Hydraulic fluid type*
- *Size*
- *Efficiency*

Compounding

Production

All Steps are completed inside FTE In House.

Material is compounded into sheets of uncured rubber.

Uncured Sheets are then compressive molded into shape.

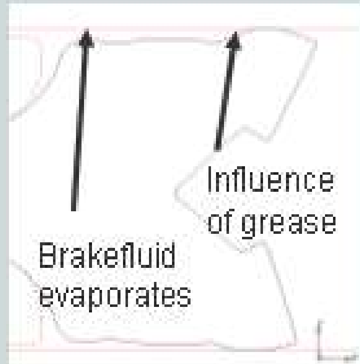
After compressive molding, the seals are machined and de-flashed.

Efficiency

The efficiency factor gets a more and more greater importance because of the higher pedal forces due to the higher torque which has to be transformed

A possibilty to improve the efficiency factor is **to reduce the friction** between sealing and sliding surface: the friction is influenced by:

- Grease
- Surface structure of the sliding area
- Surface geometry of the sealing



High friction means:

- Overheating.
- High wear.

The friction of sealings depends on complex physical interactions.

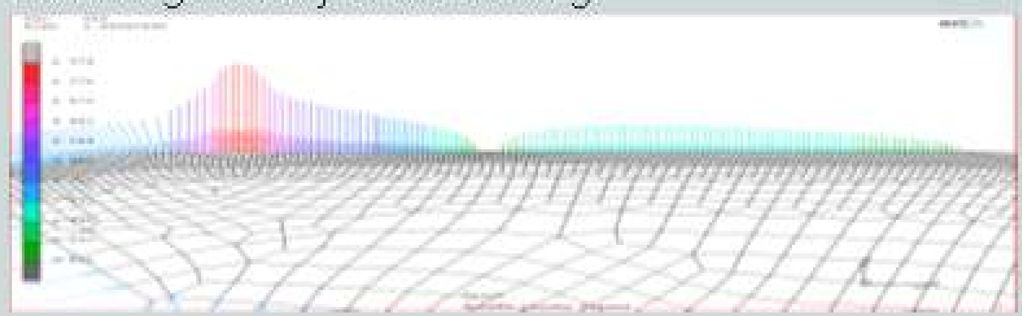
There are no general valid coefficient of friction:

The Coloumbsche law of friction

f=Fr/Fn is not valid.

The coefficient of friction decreases according to the pressure.

For elastomeres the friction depends on the real contact area.



with:

h_a = Film thickness

η = Viscosity of medium

V = Velocity

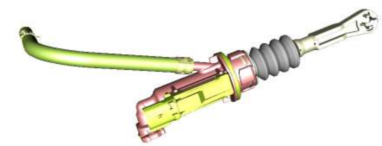
w_a = Maximum pressure gradient

$$h_a = \sqrt{\frac{2}{9}\frac{\eta N}{W_a}}$$

Parts Of The Hydraulic System - FTE Hydraulic Clutch Actuation Basics

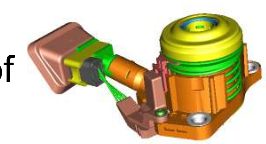
The Hydraulic Portion of the Clutch Control System is broken into four (4) Key Portions:

A. **Master Cylinder + Feeder Pipe + Reservoir** (includes pushrods and switches/sensors) – This portion of the actuation system is what is connected to the pedal. It is the input device, its function controls other portions of the actuation system.



B. **Clutch Tube** Assembly – Connects M/C to S/C. It contains any dampers, can be plastic, steel & rubber, stainless steel or a combination, and may have sleeve type heat shielding or clips or rubber isolators on it to keep it from rattling.

C. **Slave Cylinder** – Two Types-External and CSC – The function of the slave cylinder is controlled by input from the master cylinder. FTE uses two types of slave cylinders, external (mounted on the outside of the transmission) and CSC Concentric Slave Cylinder (mounted inside of the transmission and surrounds or is concentric to the transmission input shaft). The CSC includes the release bearing.



D. **Fluid** – Fluid is the element that is used to transmit motion from the master cylinder to slave cylinder. We use brake fluid because it's operating range from -40°c to 200°c has a fairly flat viscosity curve. Viscosity change with low temperature effects are not as great as with petroleum oil (mineral oil) where fluid thickness varies greatly with temperature changes. FTE system can be supplied pre-filled with added lubricant or dry for filling on the vehicle-using Dot 3 or Dot 4 fluids.

Some Higher Temperature Considerations with Brake Fluid:

Fluid boil or Vapour lock –

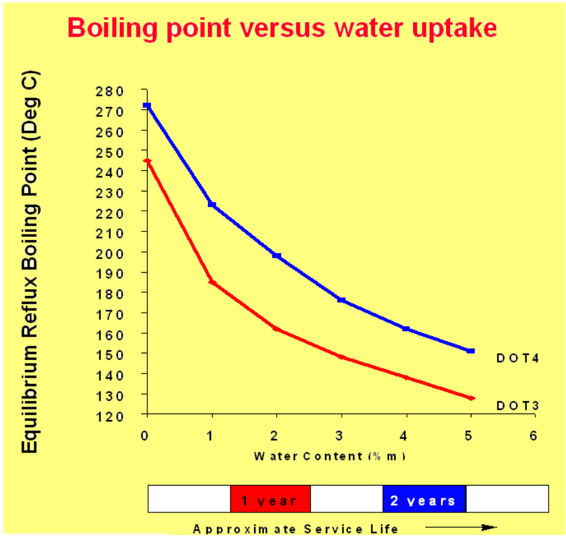
Depending on the water content in the brake fluid the boiling point will change. During vehicle life an amount of water is absorbed into the system from outside sources. The amount of water is dependant on the environment of the vehicle.

Dot 3

- Dry 205 Deg C (typical value depends on manufacture)
- Wet 140 Deg C (typical value depends on manufacture and water content see chart)

Dot 4

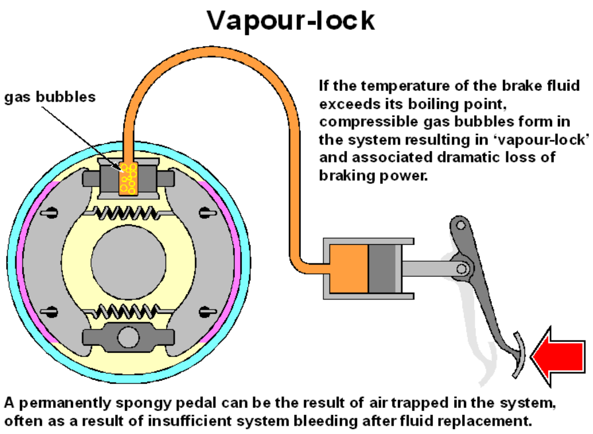
- Dry 265 Deg C (typical value depends on manufacture)
- Wet 175 Deg C (typical value depends on manufacture and water content see chart)



Some Cold Temperature Considerations with Brake Fluid:

Fluid Viscosity –

The viscosity is especially critical in respect to system response and performance at low temperatures. Number of hydraulic connections, lin diameter, and orifice sizes become critical.



Pre-filled systems

vs

Advantages

Easy installation. Assembly of 1 to 2 sub-systems versus assembly of 3 to 6 sub-components

Systems are not dependent on brake fill and location of assembly

Able to fill with lubricated brake-fluid

(special additives)

System is pre-tested insuring quality build and fill

Coupling and uncoupling of 2 piece pre-filled system insures easy assembly and service.

Disadvantages

Air entrapment during transport/handling possible.

Cost (piece price)

Non-pre-filled systems

Advantages

Cost (piece price)

Additional error proofing due to vacuum pressure fill

Routing and assembly feasible as separate components in vehicle assembly process.

Disadvantages

Dependent on customer brake-fluid

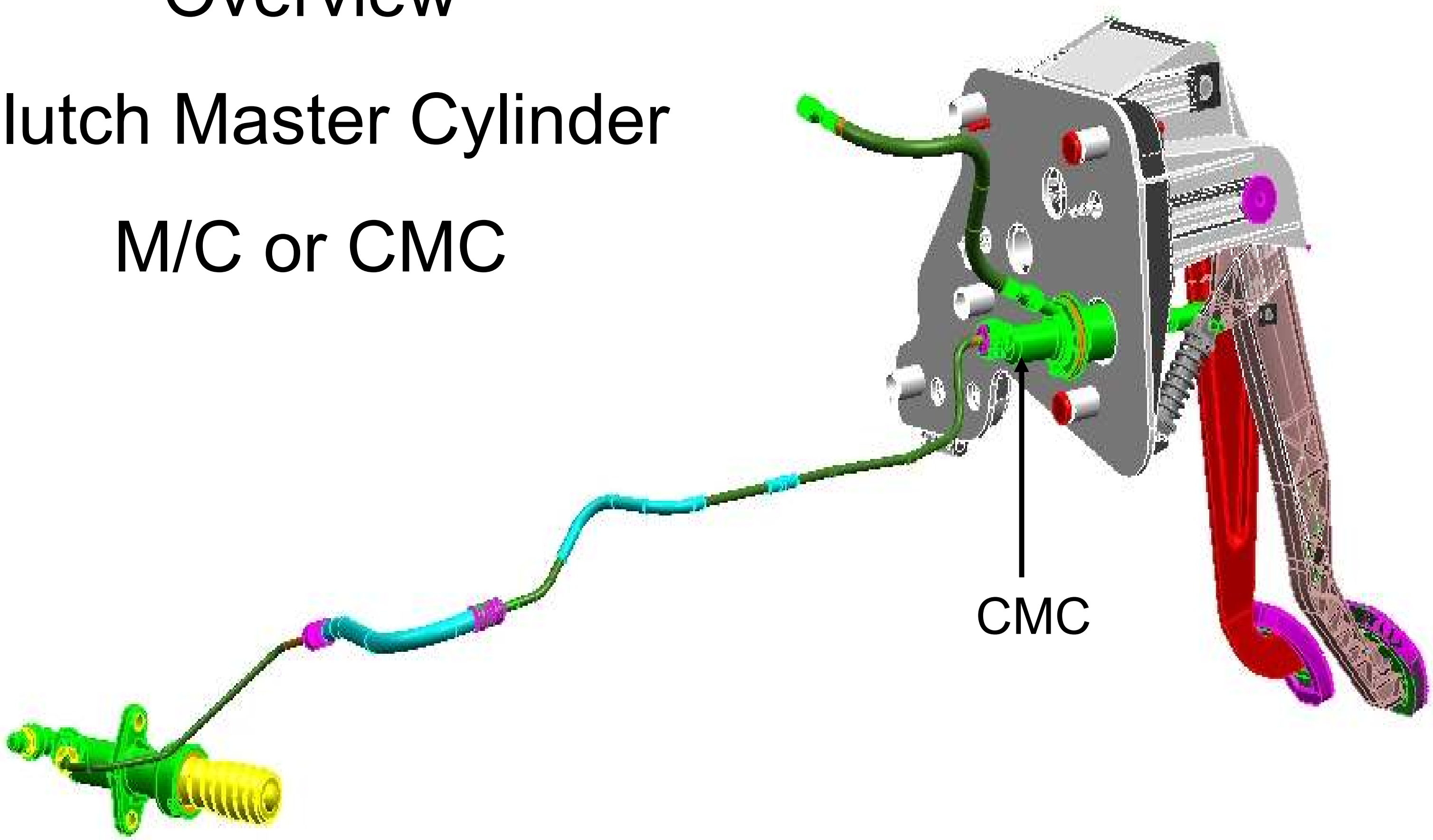
Systems are dependent on brake fill and location of assembly

Cost (assembly and labor at OE and during Service)

Overview

Clutch Master Cylinder

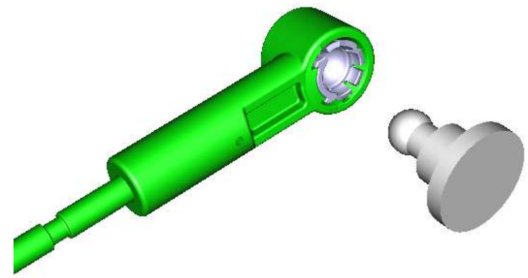
M/C or CMC



Pedal Attachments - FTE Hydraulic Clutch Actuation Basics

FTE automotive

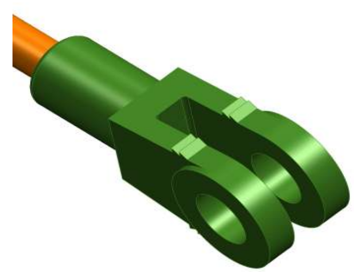
BALL AND SOCKET SNAP FIT
CONNECTION. (Ball Pin)



PISTON ROD WITH EYE ON
CYLINDRICAL PIN. SNAP FIT
CONNECTION (Cyl. Pin)

PISTON ROD WITH BALL IN SOCKET –
SNAP FIT CONNECTION (Ball Clip)

PISTON ROD WITH FORKHEAD AT
THE PEDAL, BOLT CONNECTION,
NO SNAPPING. (Fork)



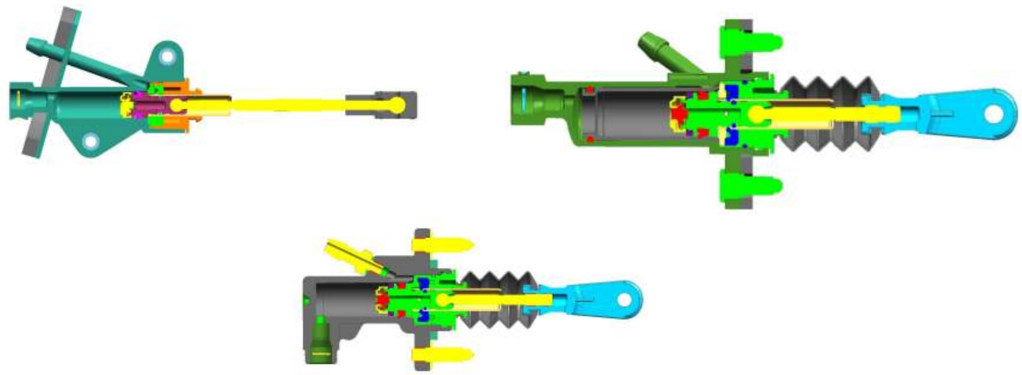
PISTON ROD WITH EYE AND
ATTACHMENT CLIP. NO
SNAPPING (Center Eye)

CMC Design Considerations - FTE Hydraulic Clutch Actuation Basics

Short build design

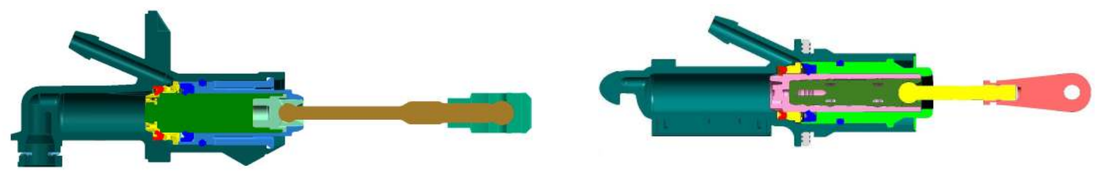
Fully plastic, metallic, plastic with metallic liner body.

Aluminum or plastic secondary sleeve.



Plunger build design

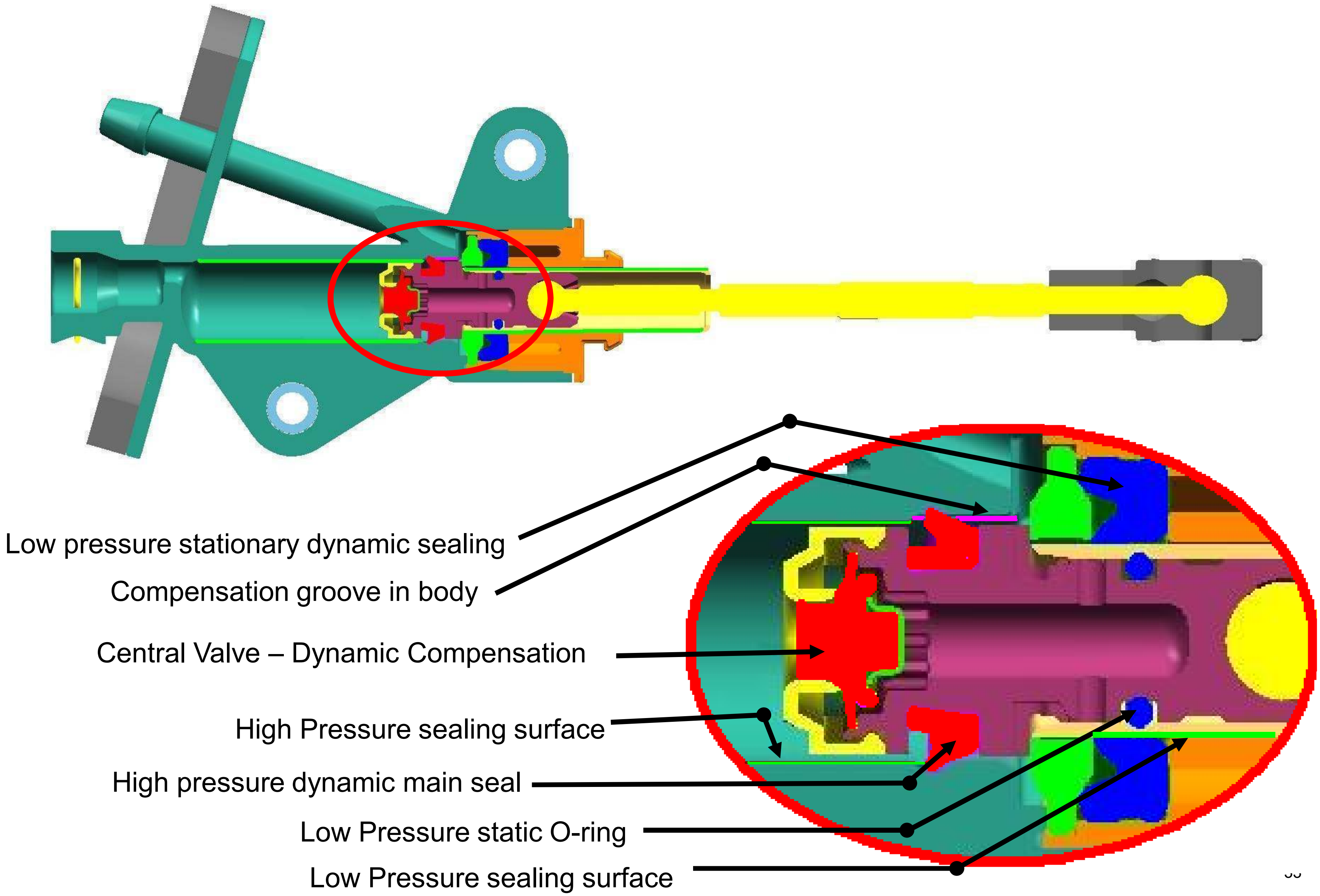
Plastic body with metallic piston and fully plastic piston design.



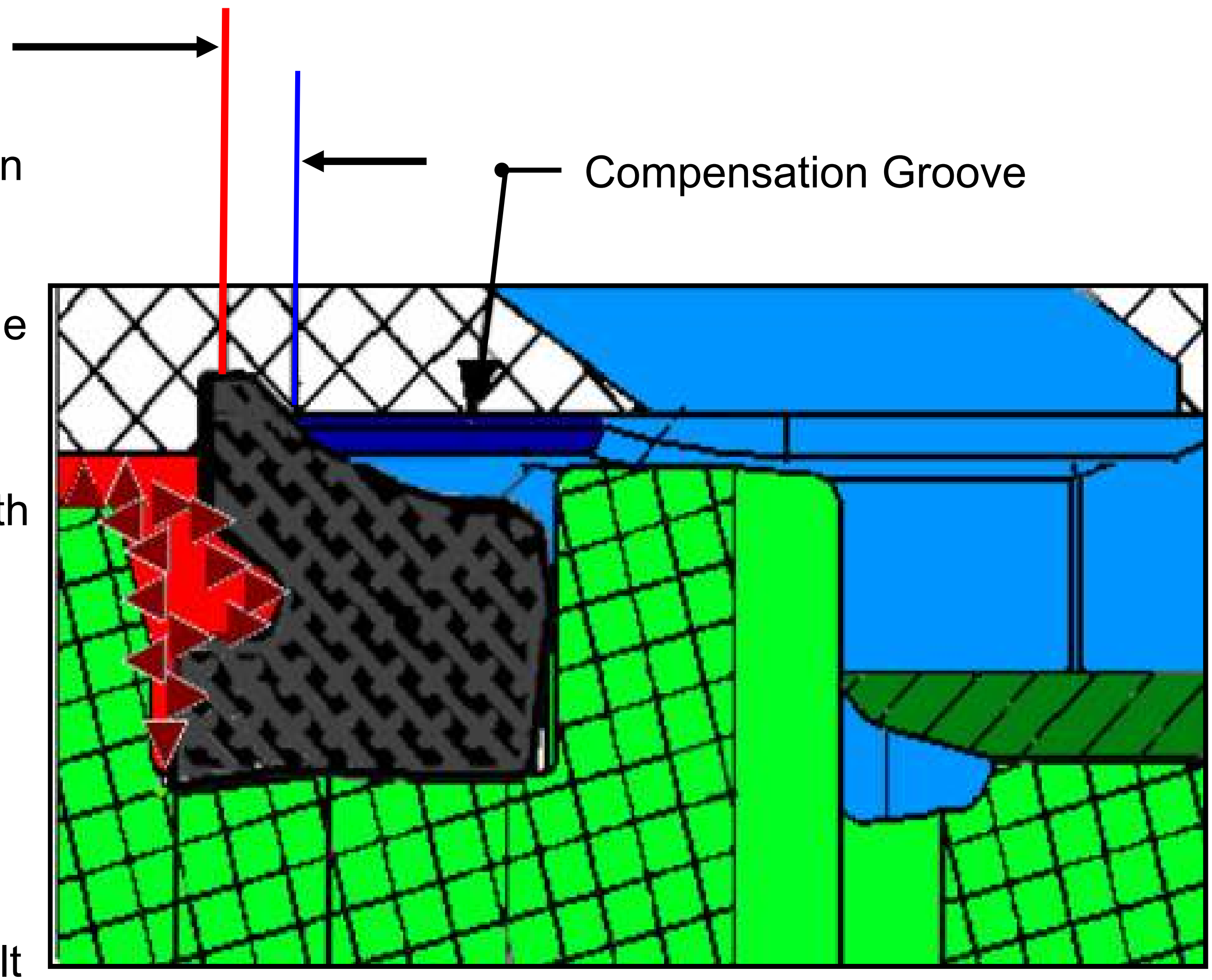
Center feed design

Fully plastic body, plastic body with metallic liner

Short Construction Design - FTE Hydraulic Clutch Actuation Basics



Compensation Clearance



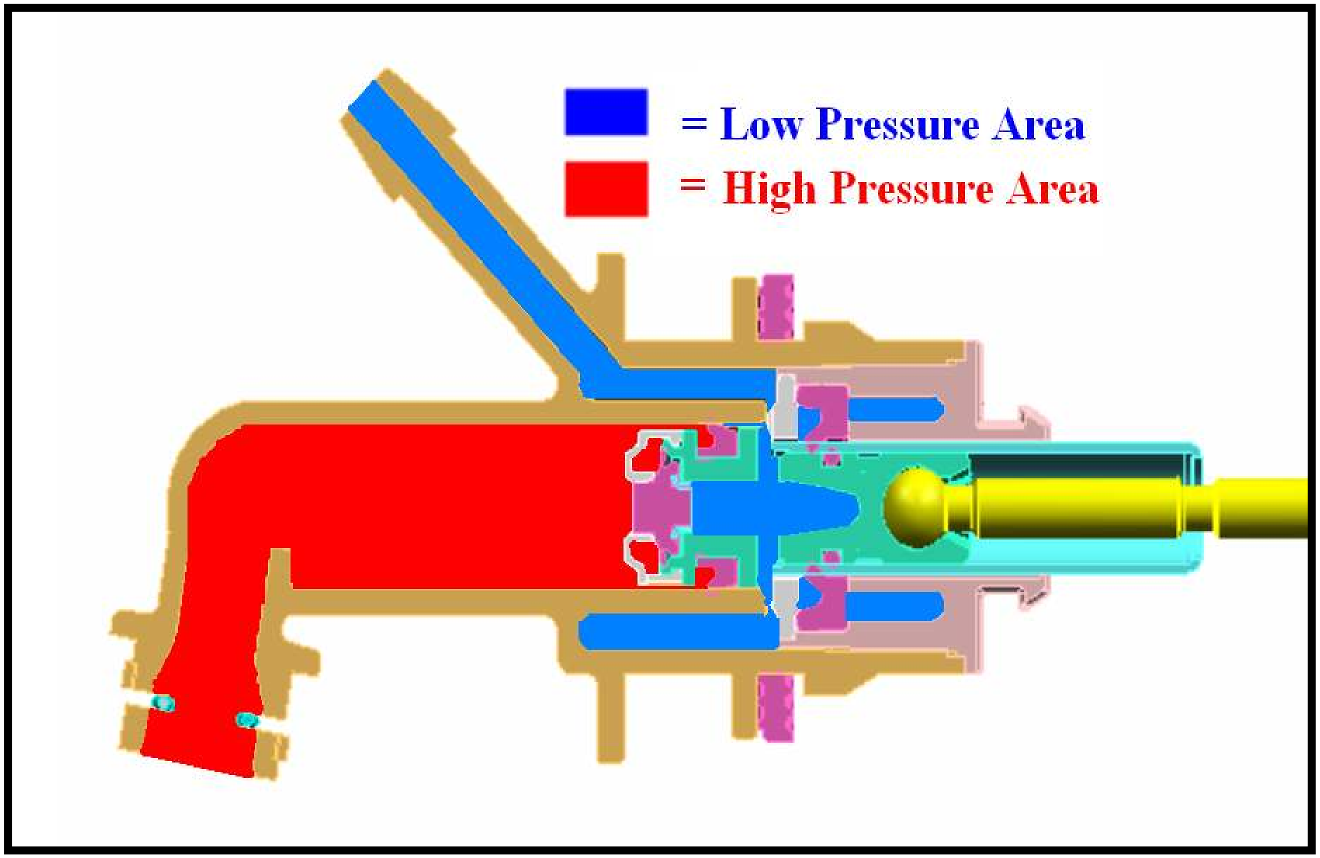
The cut-off or compensation clearance is necessary to allow the volume of fluid in the system to change as the clutch finger position changes.

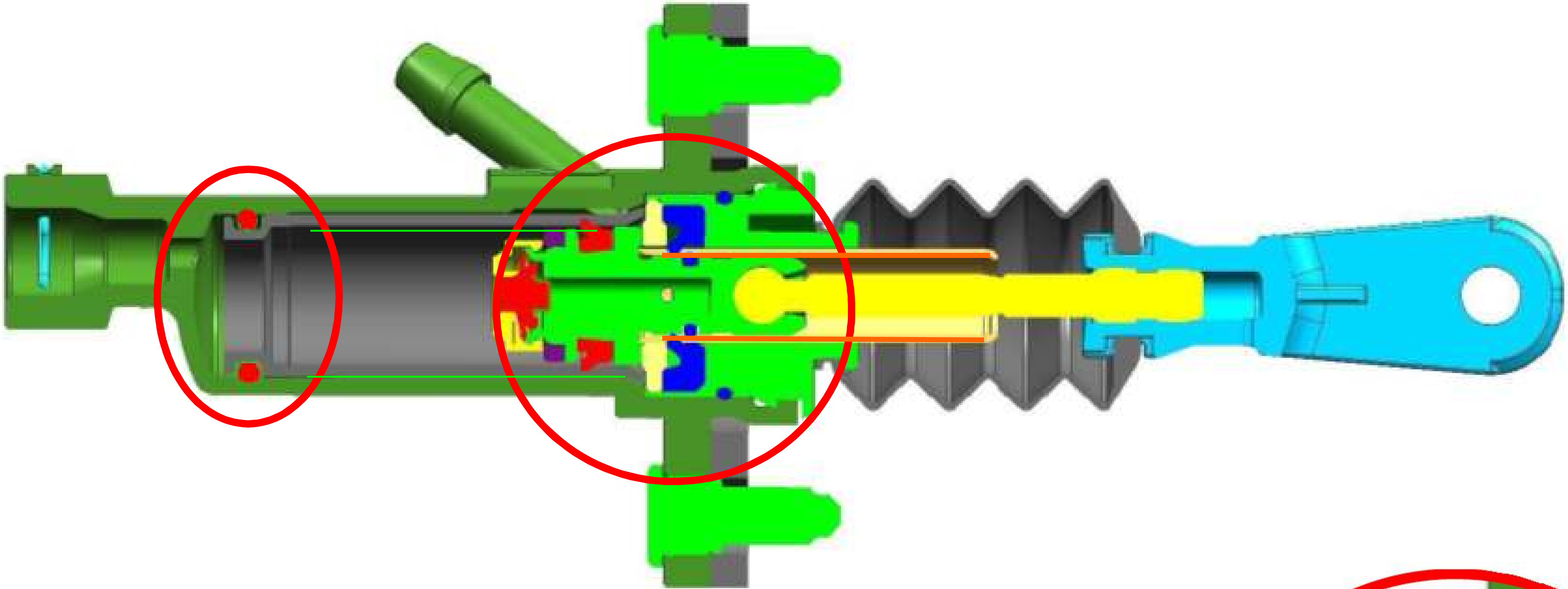
The compensation fluid path is open when the actuator/pedal is full returned.

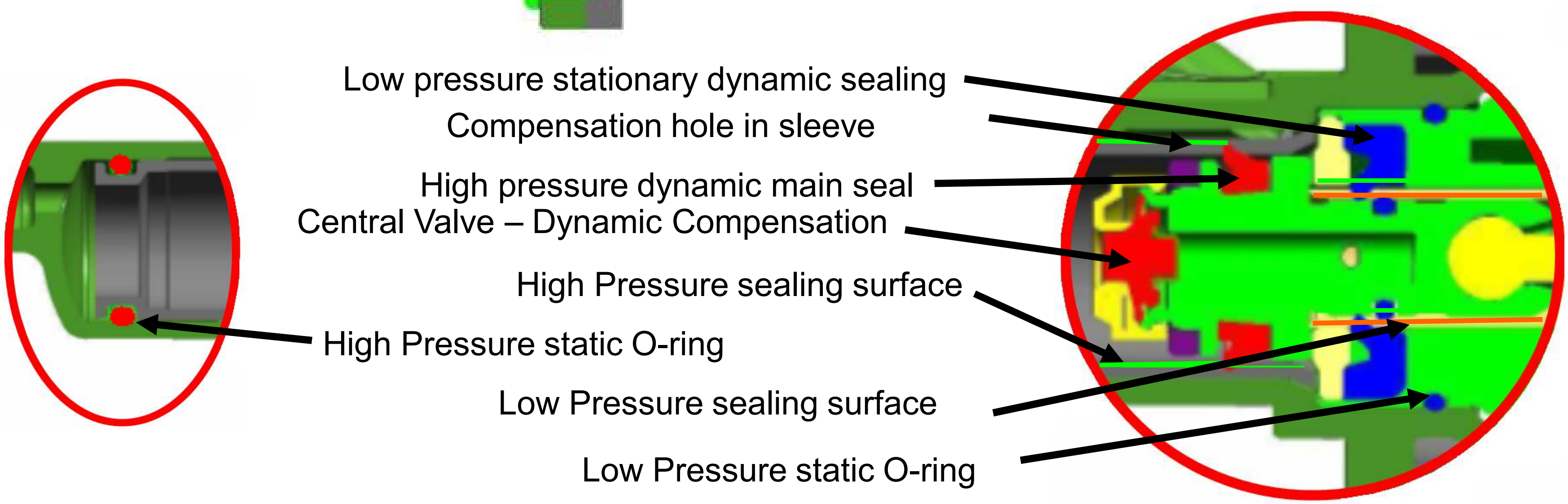
Once the dynamic seal passes over the compensation groove or hole. The seal energizes allowing pressure to be built (red area shown) and fluid transferred.

Blue portion is the low pressure area when the dynamic seal passes over the compensation groove fluid in the low pressure area is exchanged from the reservoir as necessary.

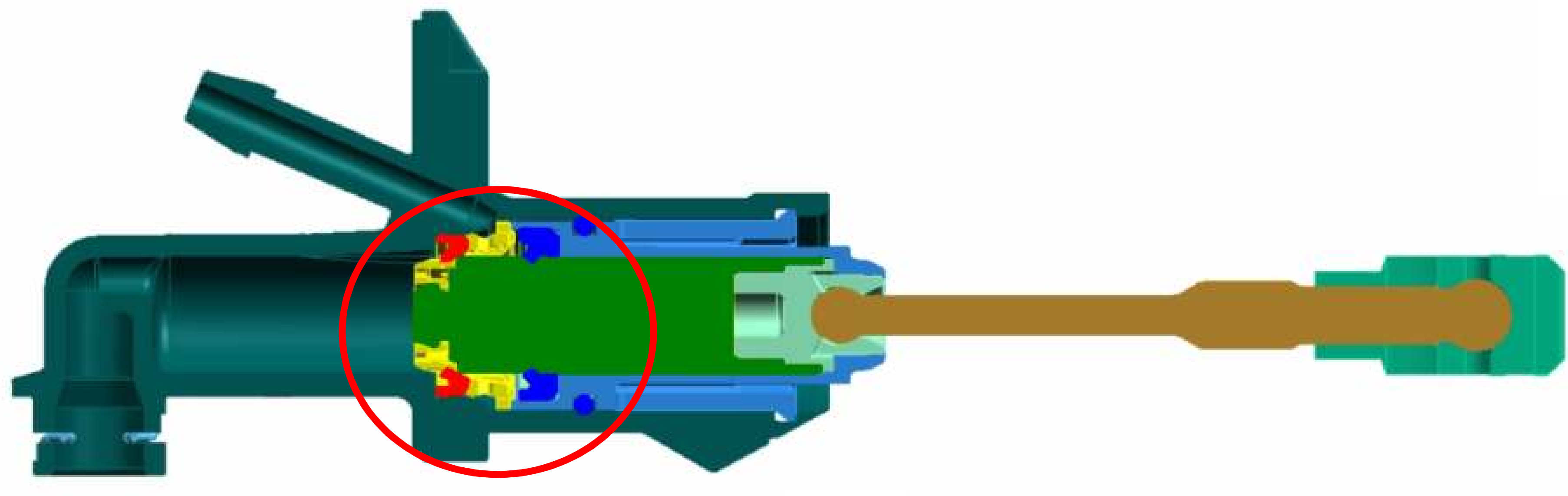
Red portion is the high pressure area when the dynamic seal passes over the compensation groove and dynamic seal is energized displacing fluid.





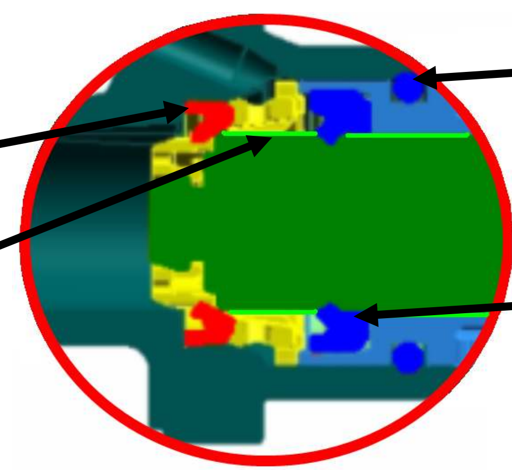

Low pressure stationary dynamic sealing
Compensation hole in sleeve
High pressure dynamic main seal
Central Valve – Dynamic Compensation
High Pressure sealing surface
High Pressure static O-ring
Low Pressure sealing surface
Low Pressure static O-ring

Plunger Construction Design - FTE Hydraulic Clutch Actuation Basics



High pressure stationary dynamic main seal

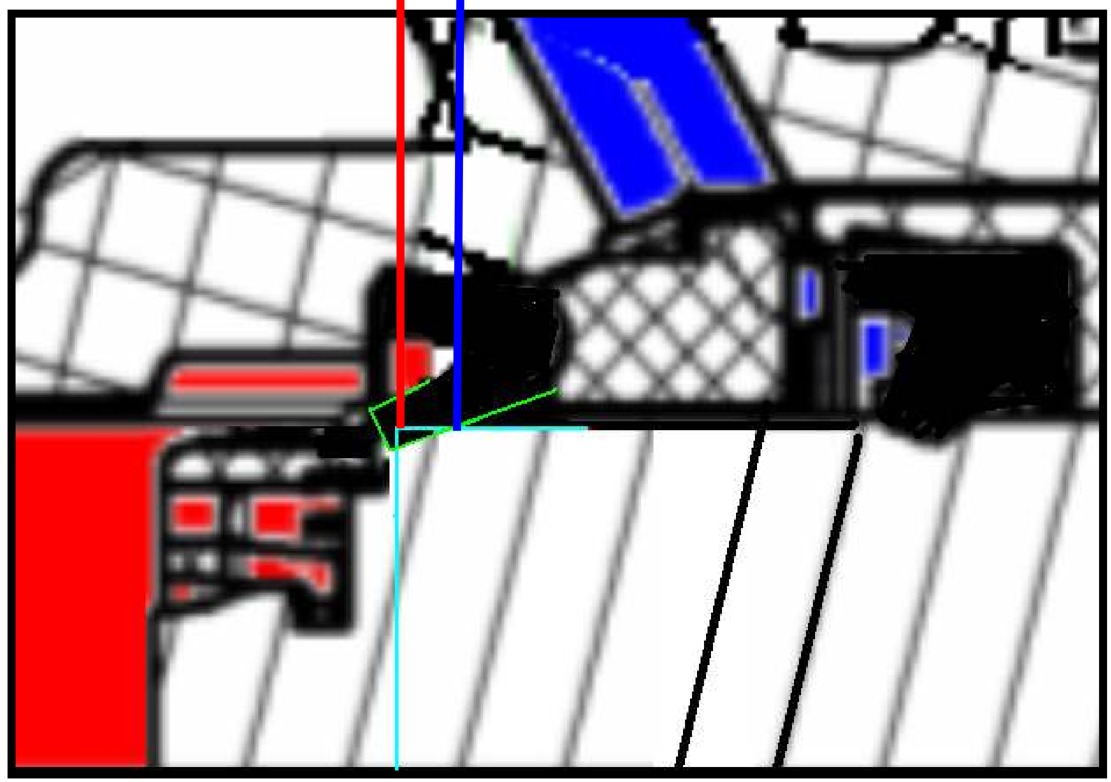
High and Low Pressure sealing surface



Low Pressure static O-ring

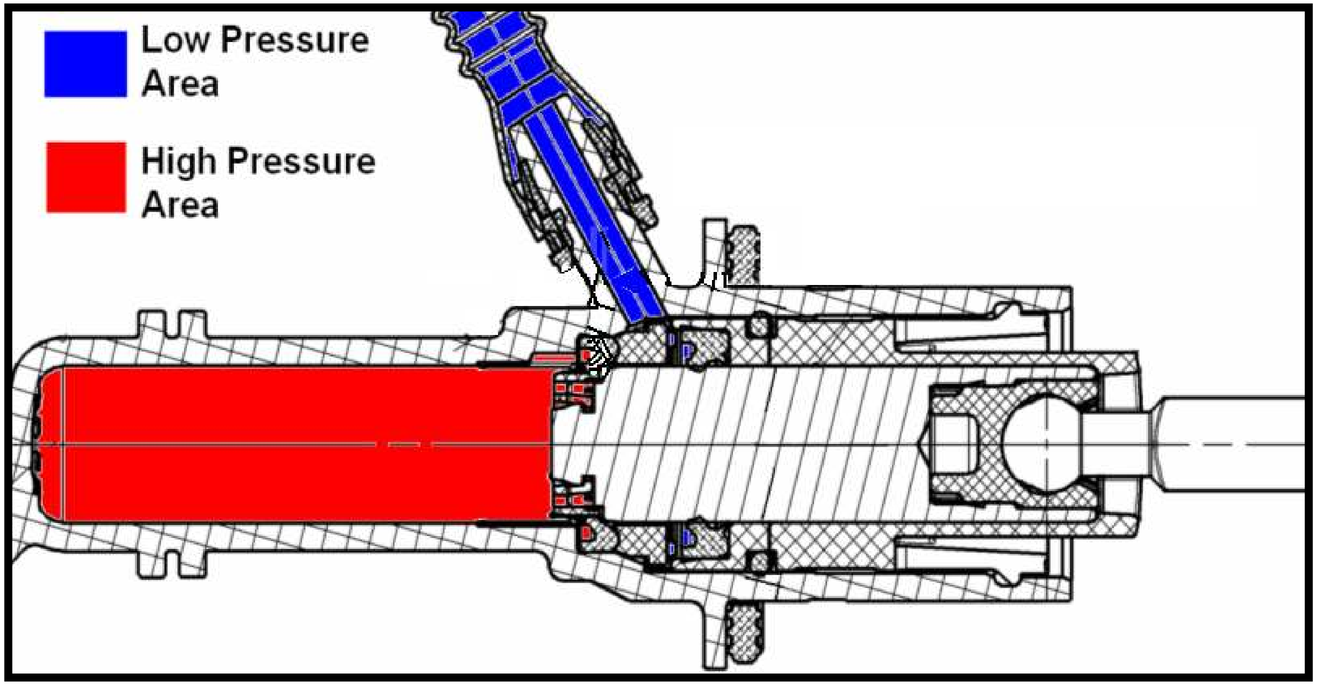
Low pressure stationary dynamic sealing

Compensation Clearance

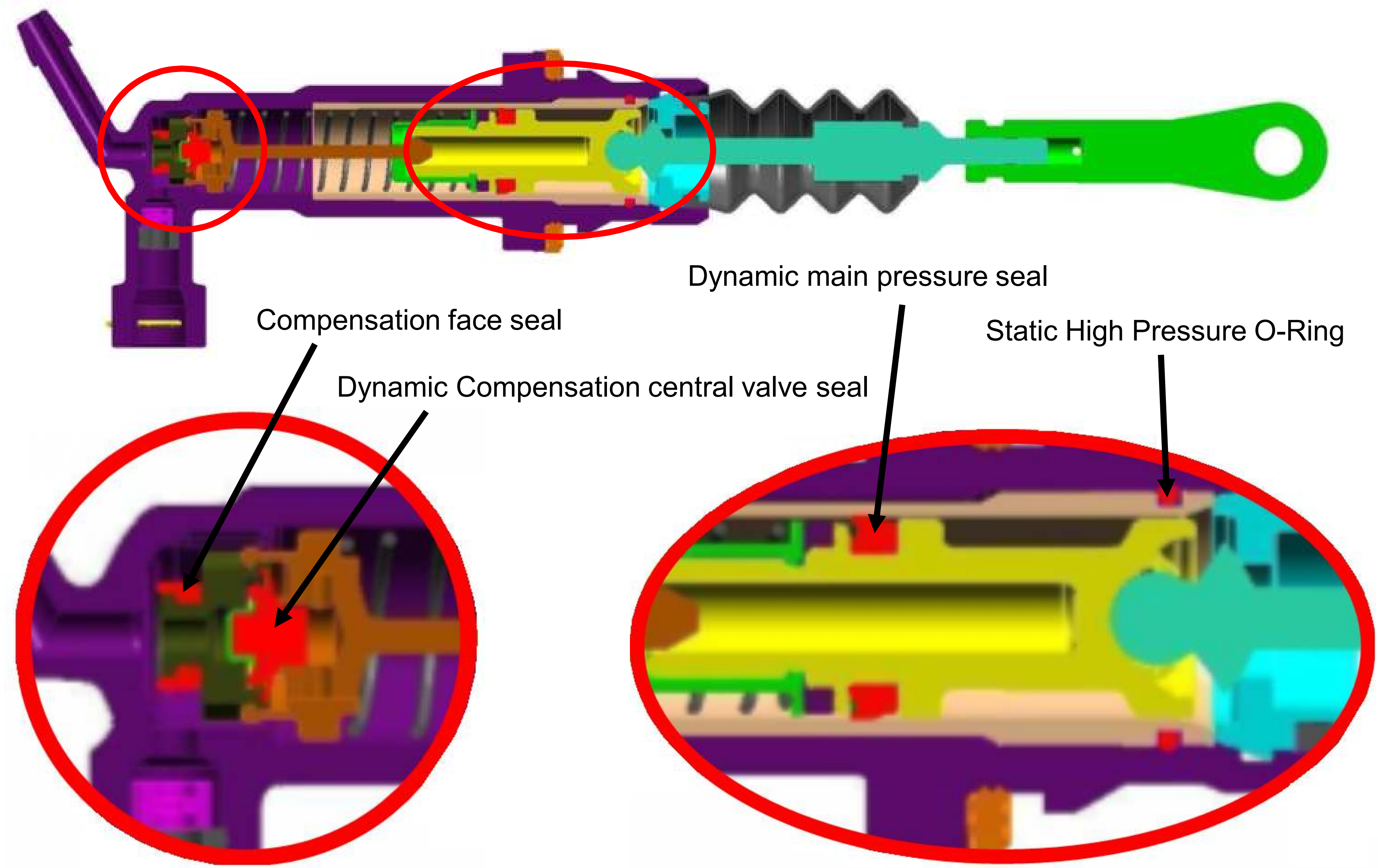


Once the sealing diameter of the piston passes by the primary stationary lip seal. The seal energizes allowing pressure to be built (red area shown) as the piston displaces fluid allowing transferring fluid.

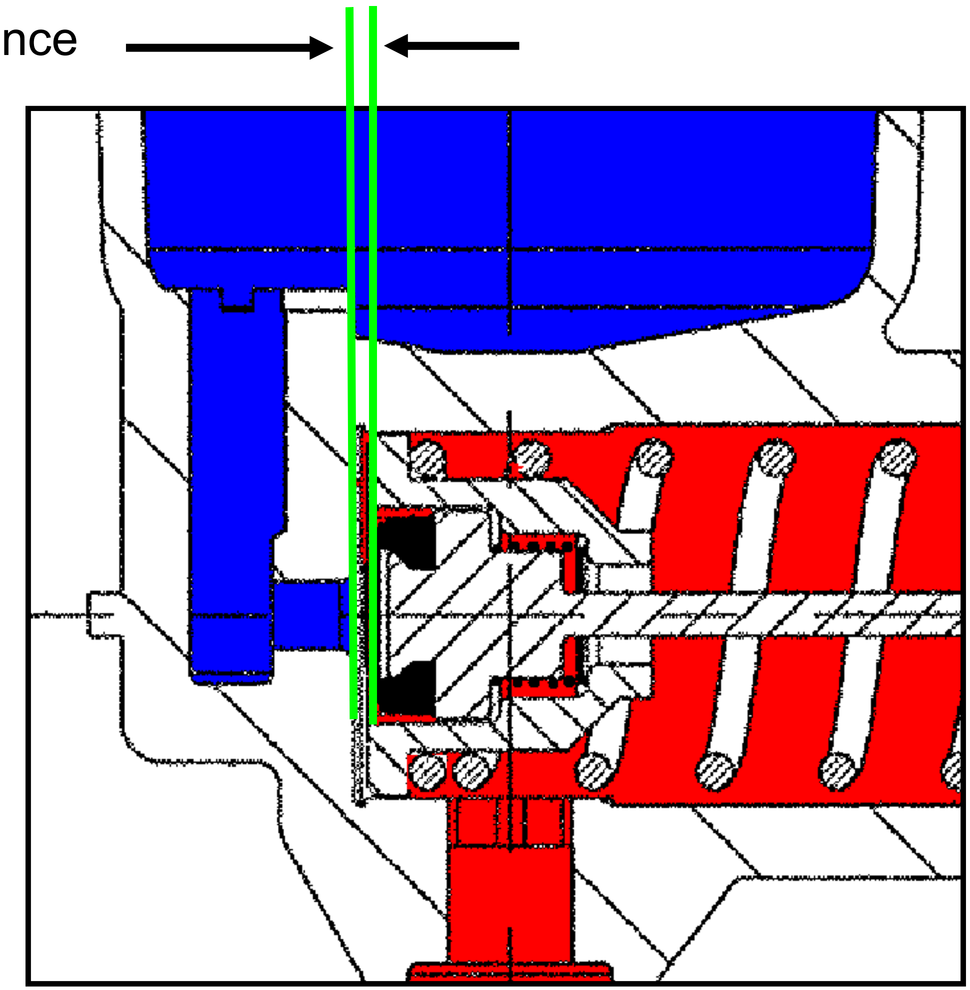
Blue portion is the low pressure area. Fluid in the low pressure area is exchanged from the reservoir as necessary when the piston is to the fully returned position.



Red portion is the high pressure area when the compensation area of the piston passes over the dynamic seal and dynamic seal is energized allowing the piston to displace fluid.


Dynamic main pressure seal
Compensation face seal
Static High Pressure O-Ring
Dynamic Compensation central valve seal

Compensation Clearance



Center feed valve on this design is a compressive seal that cut-offs or seals at the reservoir port end of the body

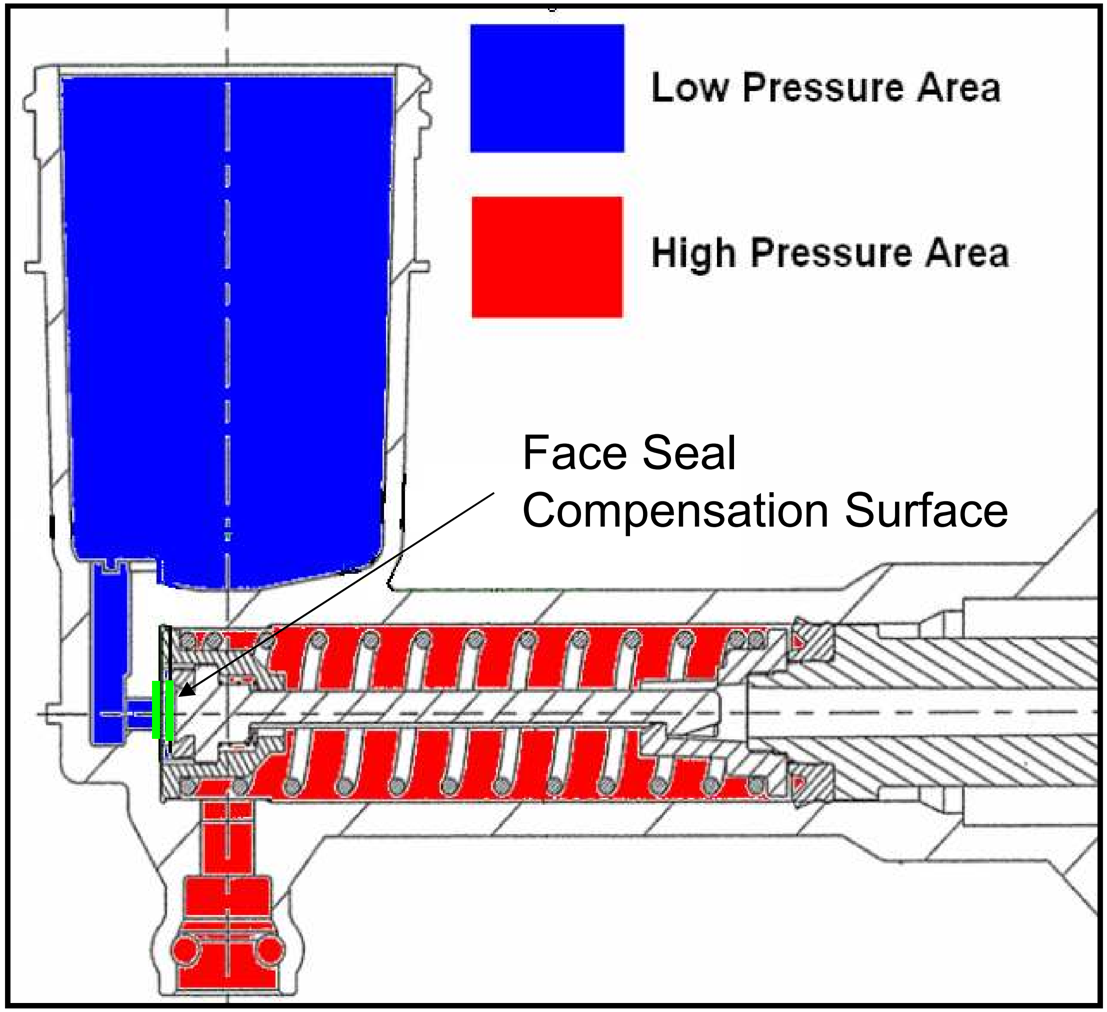
In the design pictured there is a secondary low load spring to allow for dynamic compensation.

The other type of center-feed design cuts off in the same manner but for dynamic compensation has an integrated central valve.

The hydraulic diameter is defined by the size of the bore of the cylinder.

Blue portion is the low pressure area. Fluid in the low pressure area is exchanged from the reservoir as necessary when the piston is to the fully returned position.

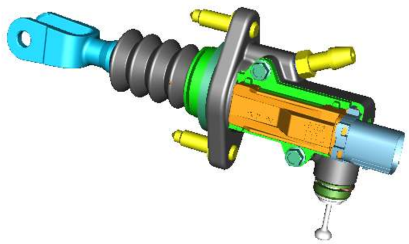
Red portion is the high pressure area when piston is actuated the face seal contacts the reservoir port area on the body sealing off the low pressure chamber allowing the dynamic seal to energize and allowing the main seal to displace fluid.



Functions of the CMC Assembly- FTE Hydraulic Clutch Actuation Basics

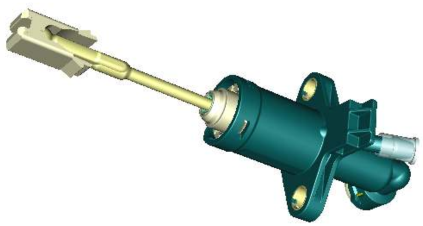
- Can act as a down-stop and up-stop for the system to reduce overall pedal tolerance.
- Provision of integral reservoir or separate reservoir based on vehicle layout
- Straight, Pre-Formed Reinforced Supply Hoses or integrated reservoir for Pre-filled or OE Filling
- Designed to operate from –40°C and 120°C
- System designed to 40 Bar
- Boots can be added to keep the system from being contaminated
- Up to a ±2° pushrod angularity capability
- Free rotating port for tube connection
- Self bleeding capability
- Self Compensates for clutch wear
- Multiple push rod to pedal attachment methods
- Integrated two function sensor or linear travel sensor to remove function from pedal box
- Multiple master cylinder body attachment methods

Two Bolt Flange Method

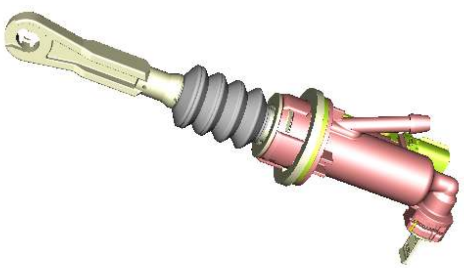


Bushing

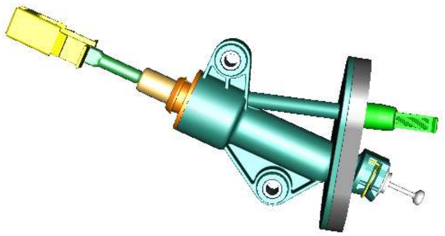
(compression limiter either threaded or through hole)



Twist and Lock



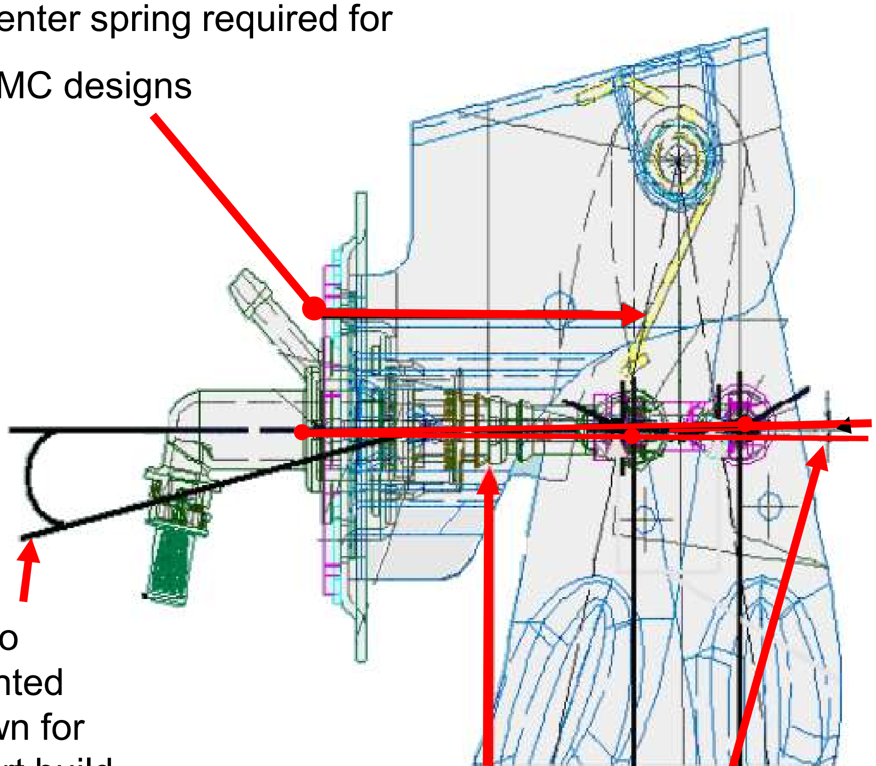
Side Saddle



Basic Packaging Considerations FTE Hydraulic Clutch Actuation Basics

FTE automotive

Return Spring or Over Center spring required for CMC designs



0° to pointed down for short build and plunger designs

0° at full travel when down stop is located on the CMC

Angularity cannot exceed ± 2 ° through out pushrod travel arc

Pedal:

A 50 N min pedal spring load measured at the pedal pin is required for short, plunger, and central valve center-feed designs.

M/C Position:

- Compensation valve needs to be at highest point.
- Feeder pipe must not have siphon.
- In short design & plunger – m/c angle toward engine side is pointed 0 degrees to down.
- In center feed – m/c angle toward engine side is pointed 0 degrees to upward.
- m/c pushrod to piston pivot must not exceed +/- 2 degrees through out full m/c stroke.

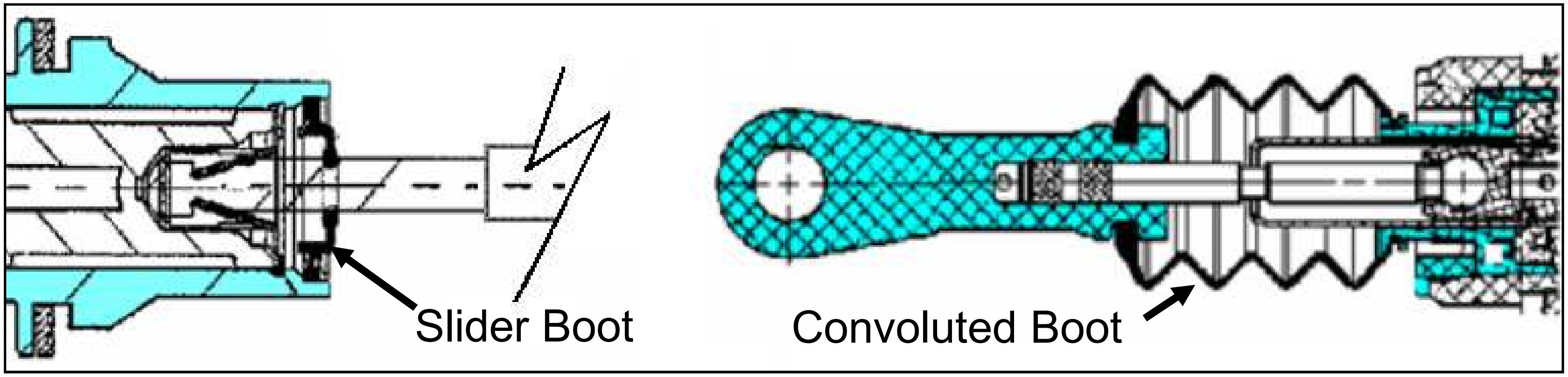
Down stop integrated into master cylinder:

0 degrees a full travel position**.**

Down stop integrated into Pedal Box

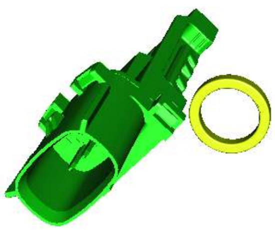
0 degrees at maximum load position.

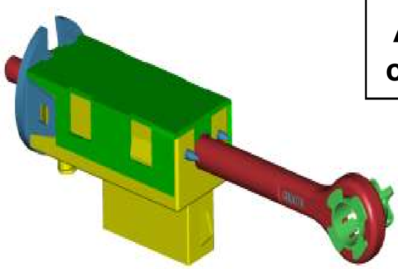
Contamination Resistance for Master Cylinder Designs



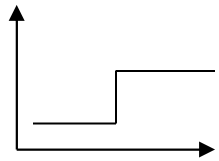
- Boots are used in applications were the environment has high levels of dust or dirt.
- Convoluted boots are more effective than slider boots to keep out contamination.
- Slider boots are used were packaging is a concern.

Sensor Technology - FTE Hydraulic Clutch Actuation Basics





Position Sensor/Contact Technology

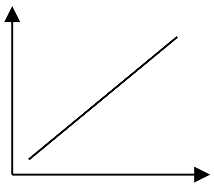


- At the clutch master cylinder/ or m/c pushrod
- At the brake master cylinder

Reed Contact and Blade Contact switch

Hall - Switch

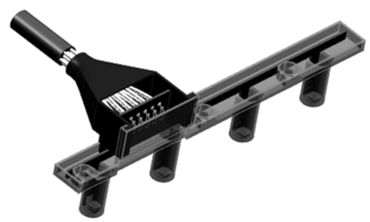
Travel Sensor Technology

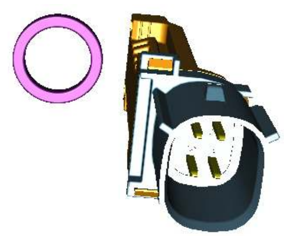


- At the clutch master cylinder
- At the clutch (external) slave cylinder
- At the concentric slave cylinder
- On the gear selector (ASG)

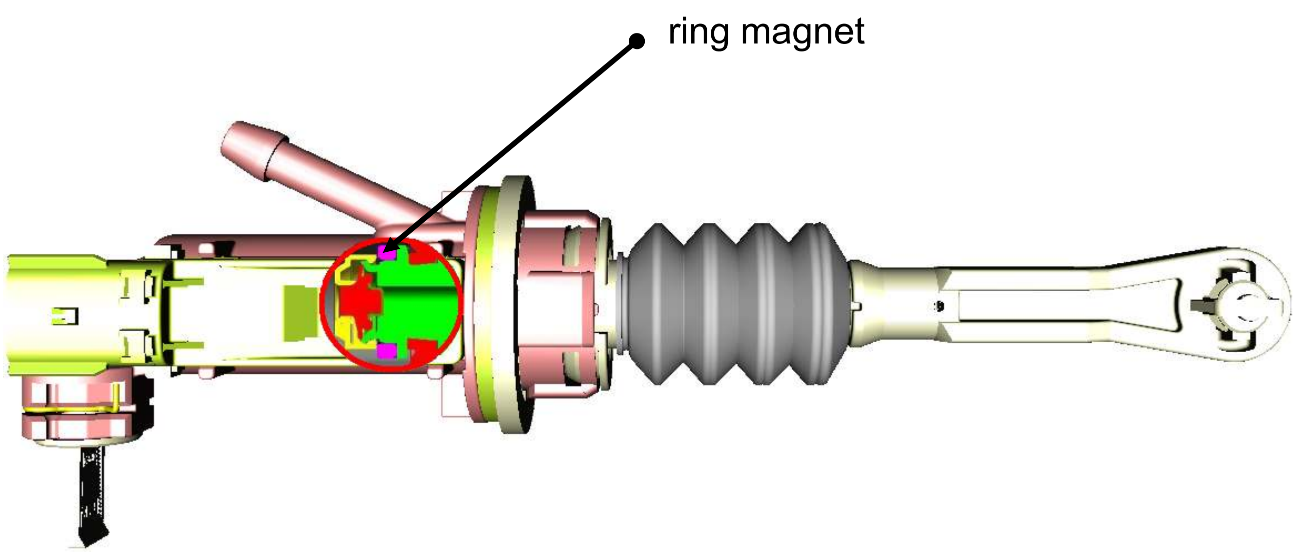
PLCD-Sensor

Hall - Sensor



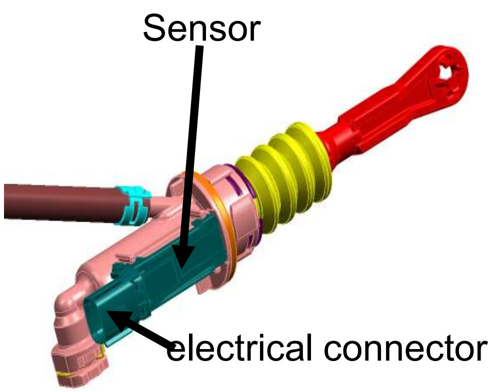


Magnetic methodology of sensing location is used for both Reed and Hall sensors.



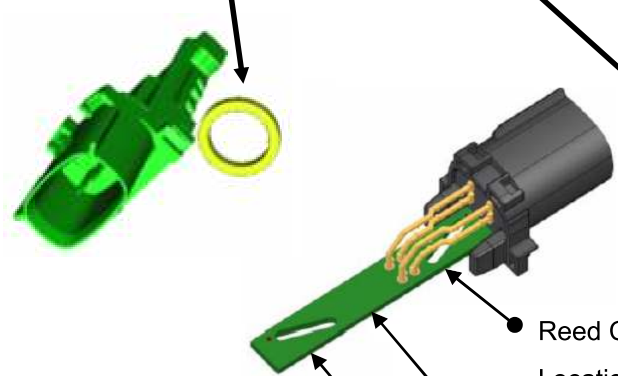
A permanent magnet transverses the switch as the piston travels forward.

CMC SHOWN:
Short built type with aluminium sleeve and sensor



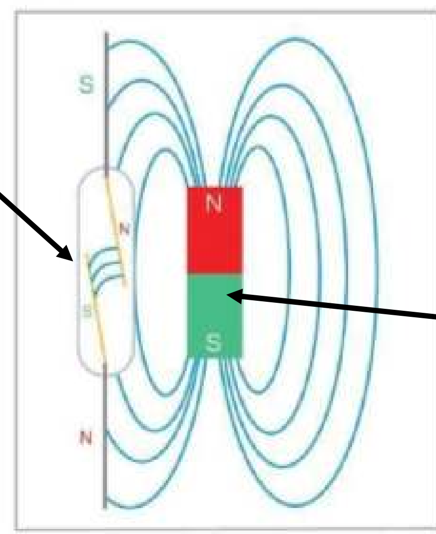
Reed Sensor Technology

Switch Point



Reed contact

Ferromagnetic contact paddles with low magnetic resistance operate in the reed switch. The paddles are sealed into a small glass tube that is filled with inert gas in order to avoid contact oxidation phenomena. The ends of the contact paddles that are arranged in parallel and that overlap are separated from each other by means of an air gap. When subject to the influence of an external magnetic field, the paddles assume opposite polarities and close if the field strength is adequate. The contact remains closed for as long as the external magnetic field acts.

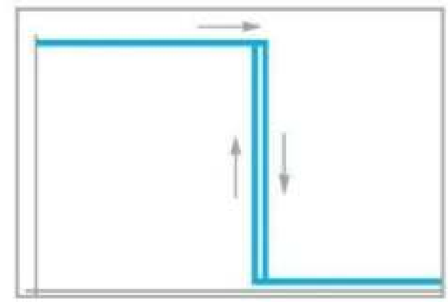


Reed switch-point sensors

Floating contact allows direct replacement of microswitches that are subject to wear. No setting work required during assembly.

Technical data

Temperature range:	-40°C - 150°C
Switching voltage:	0V - 48V
Electrical interface (U/I):	floating
Switching-point accuracy:	+/- 1mm



Hall SensorTechnology

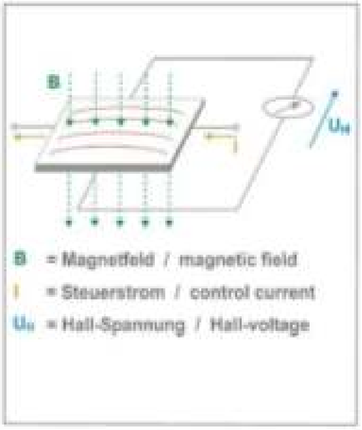
Switch Point

&

Linear Travel

Hall principle

A semiconductor wafer is arranged in a magnetic field so that the control current is perpendicular to the magnetic field. The moving charge carriers are deflected by the electrodynamic force. This leads to an accumulation of charges of one polarity at one side, resulting in a potential difference between the two sides of the semiconductor wafer, and this potential difference can be measured as the Hall voltage. The Hall voltage is directly proportional to the magnetic field running perpendicularly through the semiconductor wafer. It can be converted to a switching signal or a displacement signal.

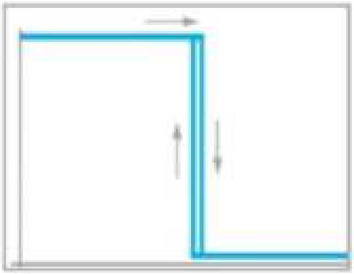


Hall switch-point sensors

The switch-point sensor integrated in the clutch master cylinder functions as a switch and replaces the functions of the pedal switches, for start-lock and cruise control for instance. Owing to the non-contact mode of operation, the sensor is not subject to wear, operates silently and is exceedingly resistant to vibration.

Technical data

Temperature range:	-40°C - 150°C
Electrical interface (U/I):	low-side/high-side switch
Supply voltage:	3.8V – 24V
Switching-point accuracy:	+/- 0.5mm



Hall displacement sensors

A displacement sensor produces a constantly rising output characteristic over its measuring range.
The integrated displacement sensor functions as an absolute displacement measuring element and measures the position of the plunger. The output signal (voltage signal) is directly proportional to the plunger travel.
There is an option for a combination of position sensor and displacement sensor.

Hall displacement sensor HF-DS

Technical data

Temperature range:	-40°C - 150°C
Supply voltage:	5V or 12V
Electrical interface (U/I):	PWM
Measuring range:	10 - 50mm

Hall displacement sensor DHA-DS

Technical data

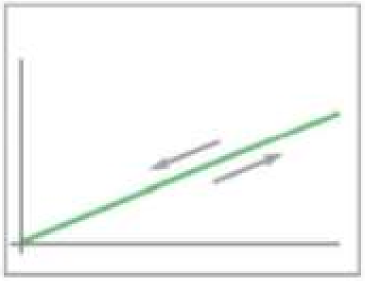
Temperature range:	-40°C - 150°C
Supply voltage:	5V or 12V
Electrical interface (U/I):	PWM / LIN bus
Measuring range:	10 - 50mm

For high accuracy requirements

Hall displacement sensor DHS-DS

Technical data

Temperature range:	-40°C - 150°C
Supply voltage:	5V or 12V
Electrical interface (U/I):	PWM / voltage
Measuring range:	50 - 100mm



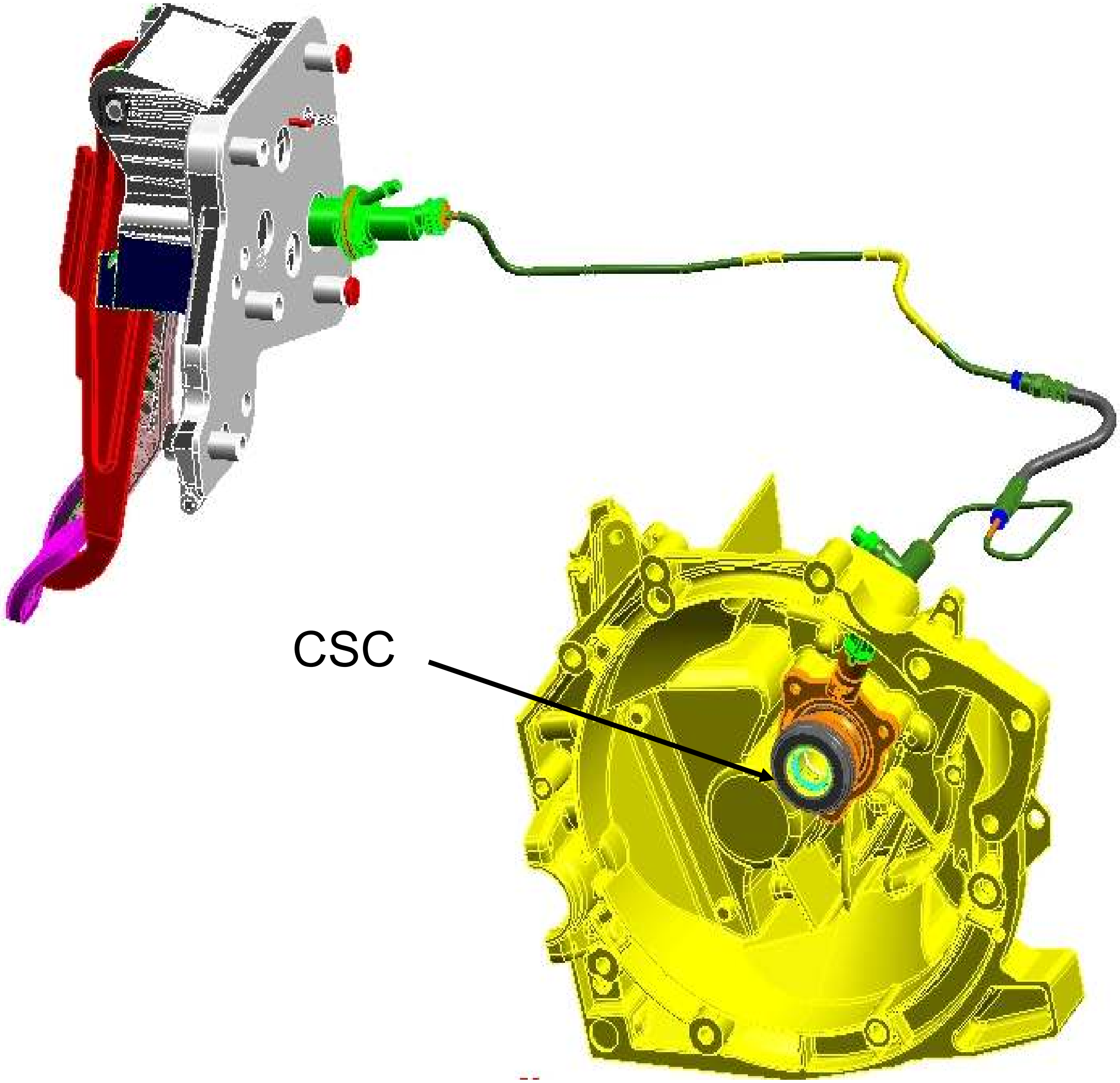
Over View

Concentric

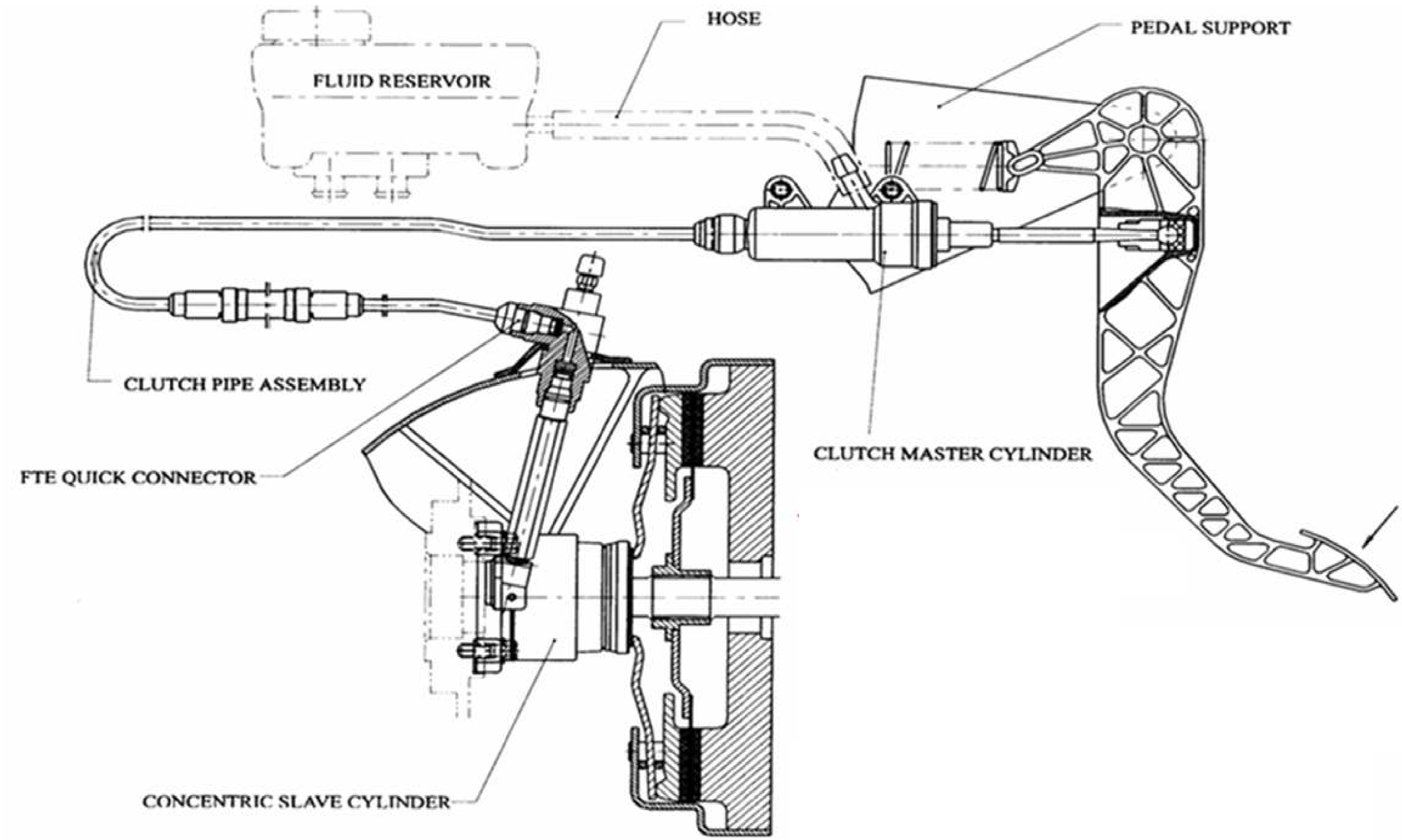
Slave

Cylinder

CSC



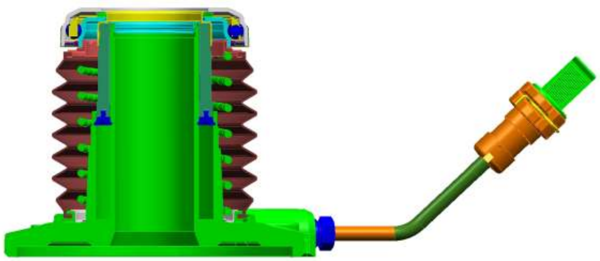
CSC Overview - FTE Hydraulic Clutch Actuation Basics

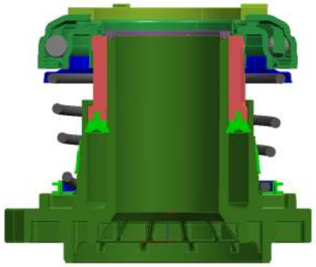


One Piece Design

Fully aluminum or plastic

(Aluminum either forged or cast)

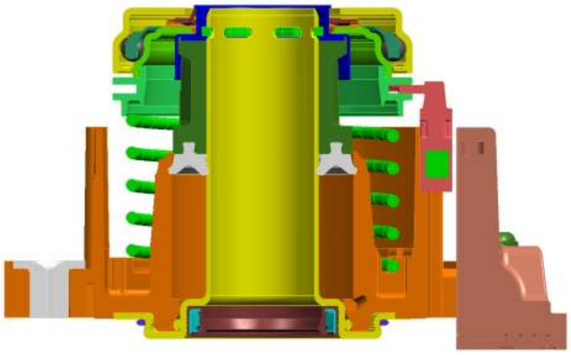


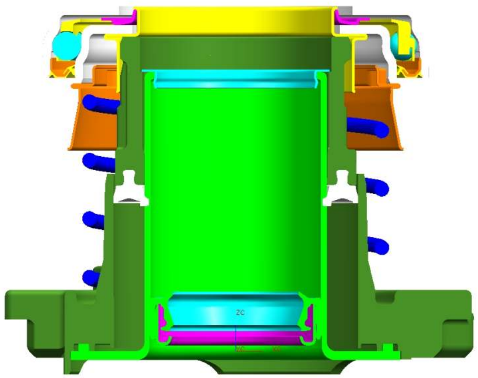


Two Piece Design

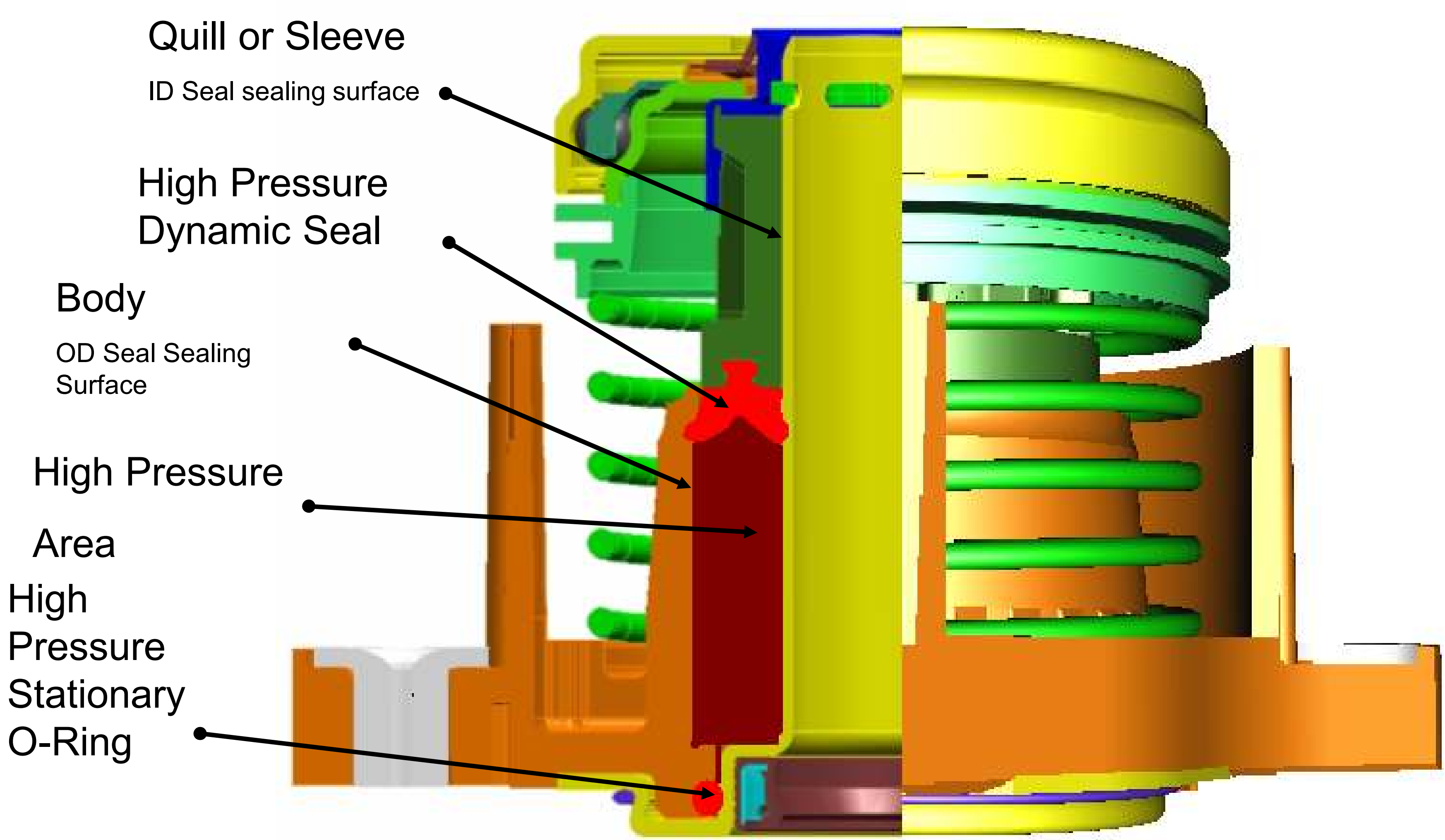
Steel Quill (sliding sleeve)

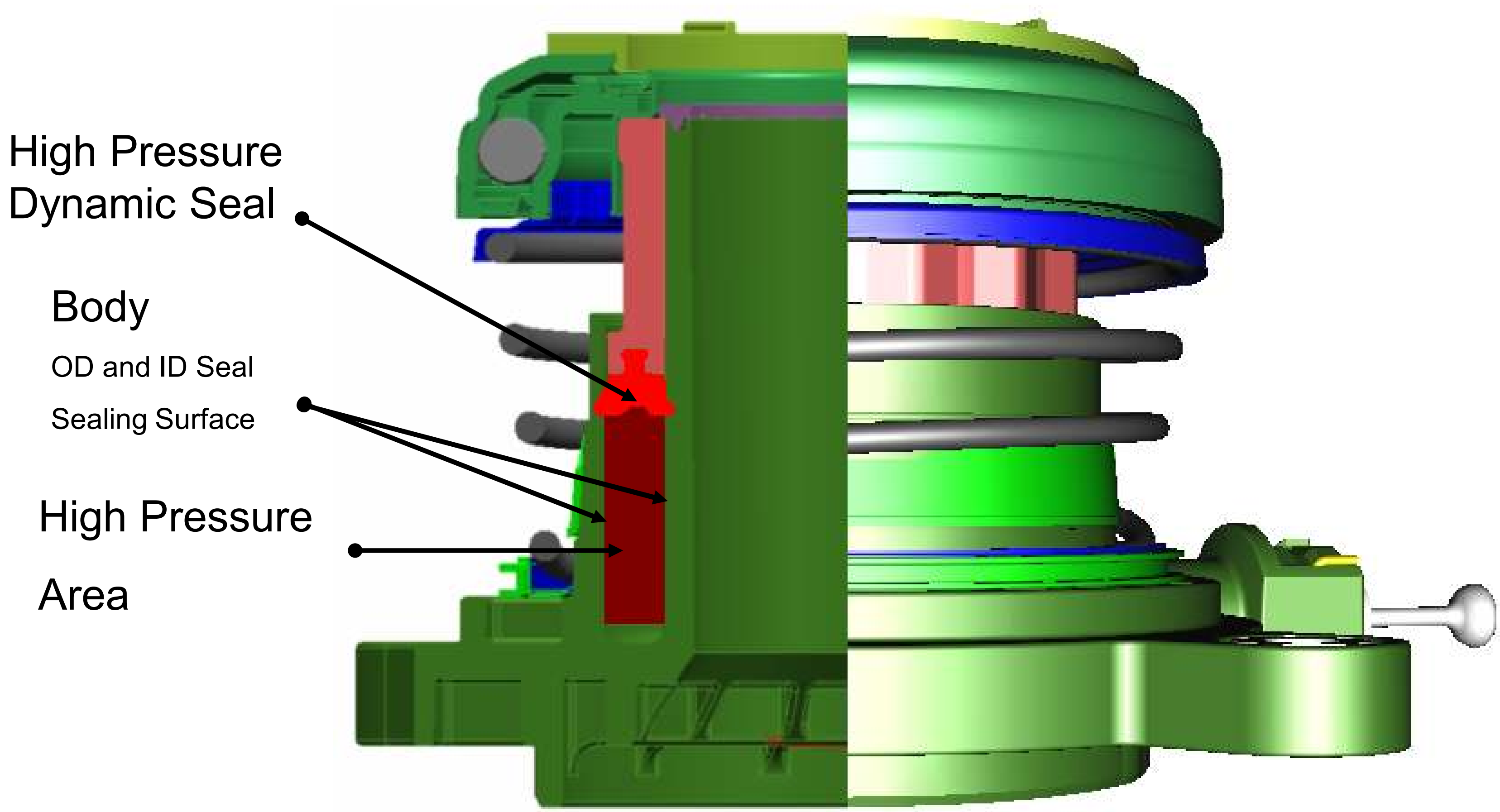
with Aluminum or plastic body





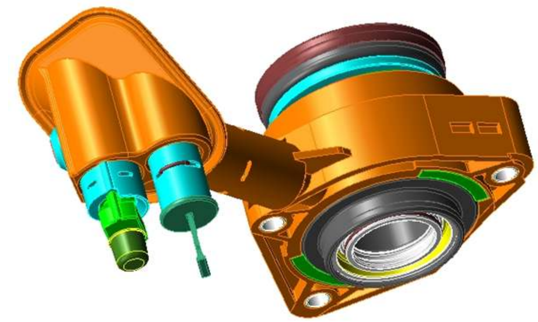
Two Piece Design Main Sealing- FTE Hydraulic Clutch Actuation Basics

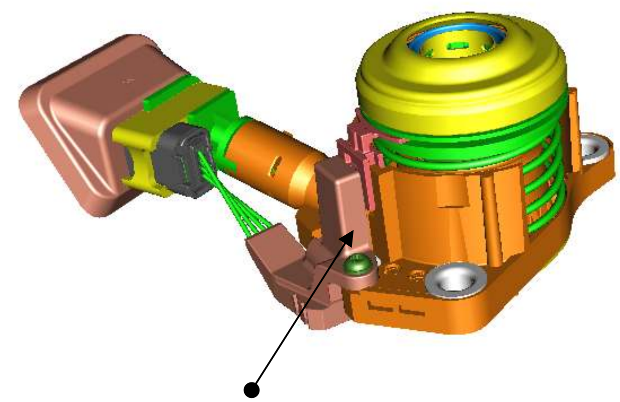



High Pressure
Dynamic Seal
Body
OD and ID Seal
Sealing Surface
High Pressure
Area

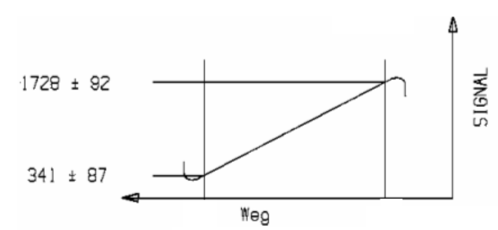
Functions of the Concentric Slave Cylinder

- Designed to operate from –40°C and 150°C with intermittent peaks of greater temperature depending on materials used. (167 °C to 180 °C)
- System designed to 40 Bar
- Self bleeding capability
- Self Compensating for clutch wear position.
- Constant rotating flat face or round face , self centering release bearing. Sealed release bearing available for long life and contamination resistance
- Integrated pressure-bleed line assembly possible for serviceability
- Convoluted boot can be used for contamination resistance
- Quick connector (dry or wet)
- Preload load for required bearing spring load
- PLCS Travel Sensor (either active or passive) integration possible using Magnetic sensing technology.

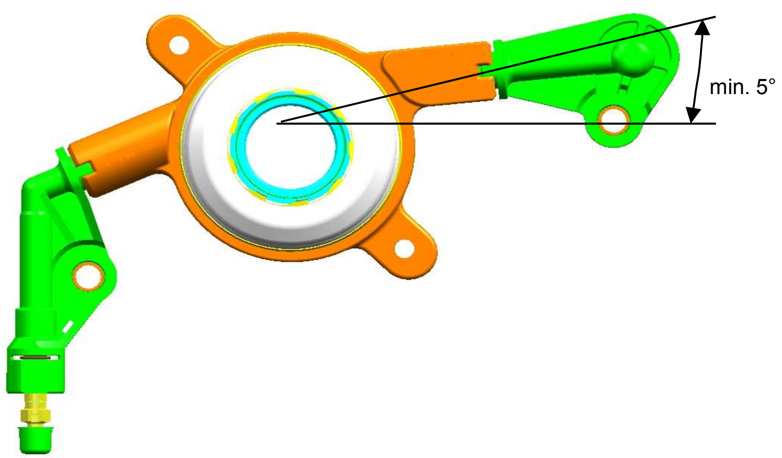


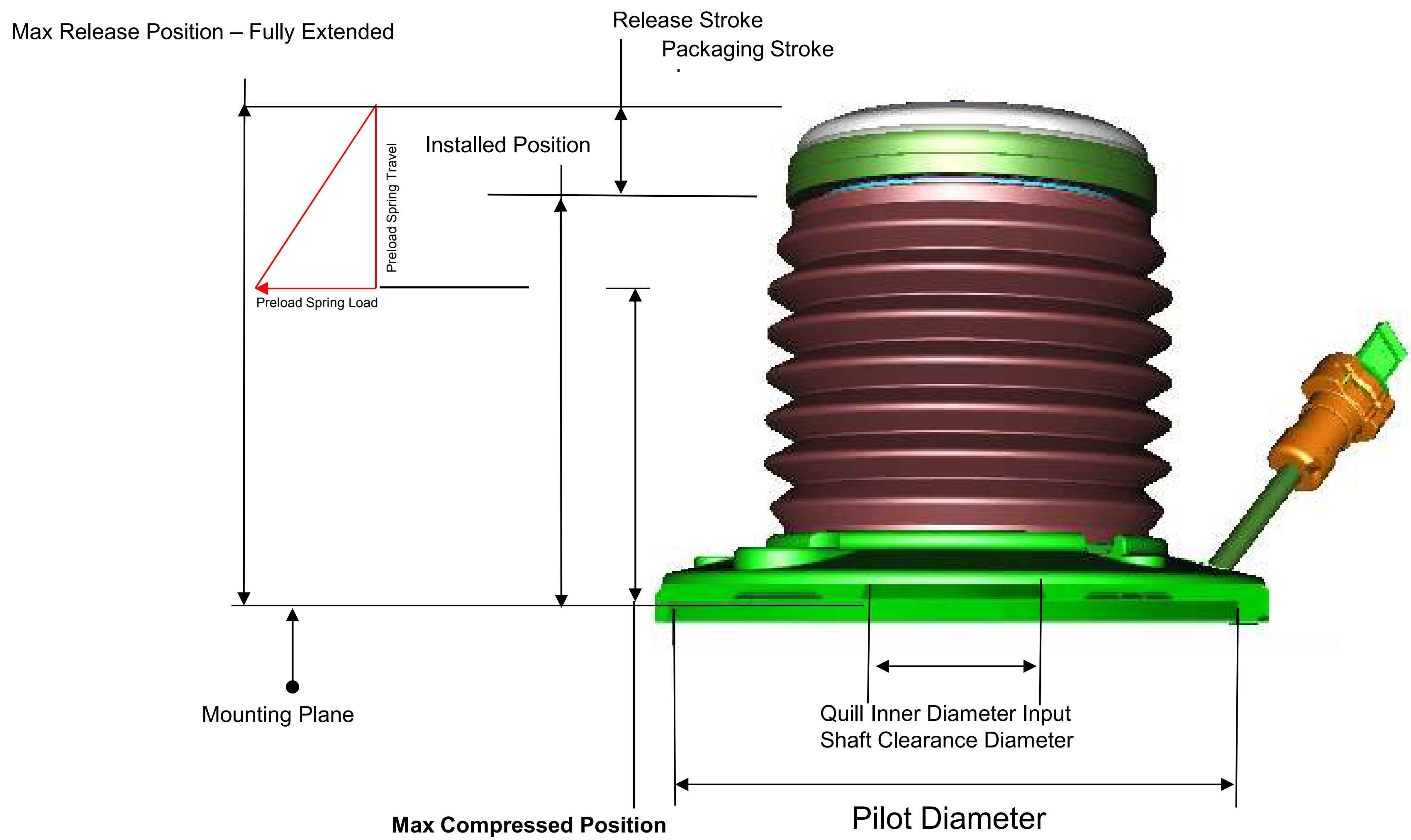


PLCD Sensor

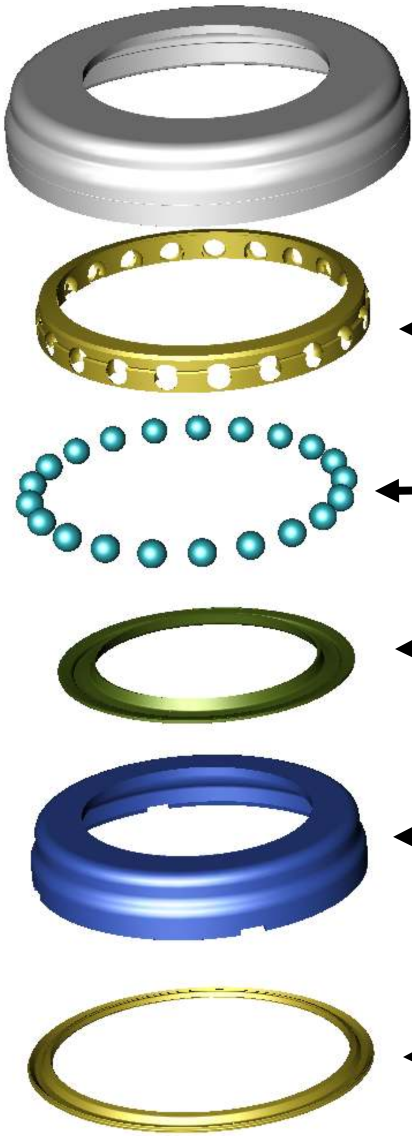


- CSC Pressure port should be angled 5 degrees from horizontal to help self bleeding.
- Packaging Stroke = Wear +Actuation Stroke+ Tolerances
- Fully Extended height from transmission mounting surface to front of bearing face.
- Fully Compressed Dimension from transmission mounting face to front of bearing face
- Preload Spring Load at height
- Pilot Diameter
- Inside Quill Diameter (clearance to input shaft)
- Max Quill Height
- Finger Contact Area & Finger Type (Round or Flat)




Max Release Position – Fully Extended
Release Stroke
Packaging Stroke
Installed Position
Preload Spring Travel
Preload Spring Load
Mounting Plane
Quill Inner Diameter Input
Shaft Clearance Diameter
Max Compressed Position
Pilot Diameter

Basic Bearing Terminology - FTE Hydraulic Clutch Actuation Basics



Outer Ring or Outer Race - Contact surface for the cage balls are referred to as the raceway. In this example this is the rotating race. Additionally contact surface for the clutch fingers.

Cage – Retains the cage balls into place

Cage Balls – Radial load to axial load

Front seal - Either contact or non-contact (Labyrinth sealing). Used to keep out outside contamination.

Inner Ring or Inner Race - Contact surface for the cage balls are referred to as the raceway. In this example this is the fixed (stationary) race

Rear seal : Either contact or non contact (Labyrinth sealing). Used to hold the grease inside the bearing and prevent outside contamination.

Grease – Reduces friction (heat generation) inside the bearing.

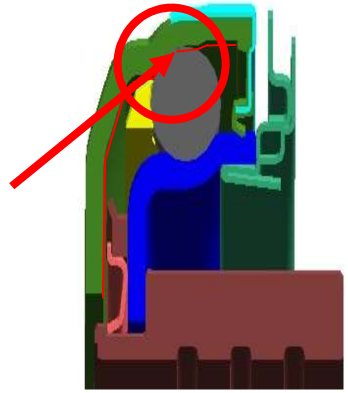
Bearing Types and Piston Attachment - FTE Hydraulic Clutch Actuation Basics

Outer Rotating Over Hang Bearing: Bearing contact surface shown is flat for round fingers. Bearing overhangs the piston for greater packaging space.

Outer Rotating

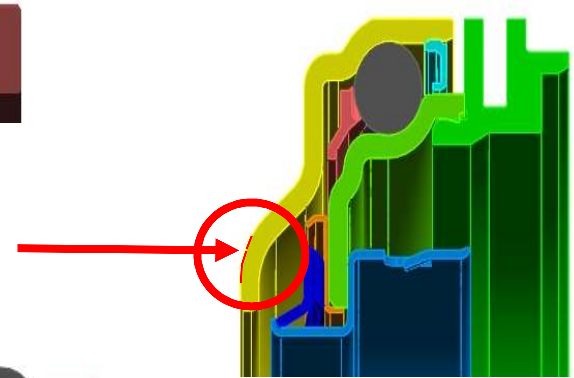
Contacting Race

Area



Outer Rotating Over Hang Bearing: Bearing contact surface shown is round for flat fingers. Bearing overhangs the piston for greater packaging space.

Round clutch finger contact surface on outer Race

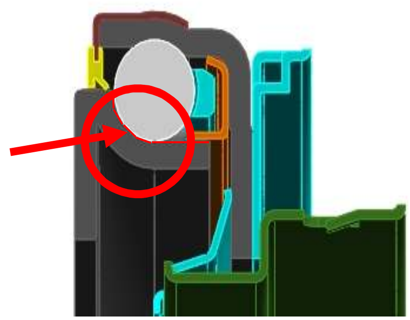


Inner Rotating Bearing: Used normally for large clutch applications as ball contact area is less. Bearing contact surface shown is flat for round clutch fingers.

Inner Rotating

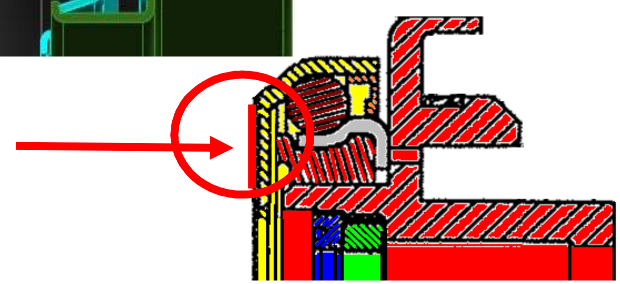
Contacting Race

Area

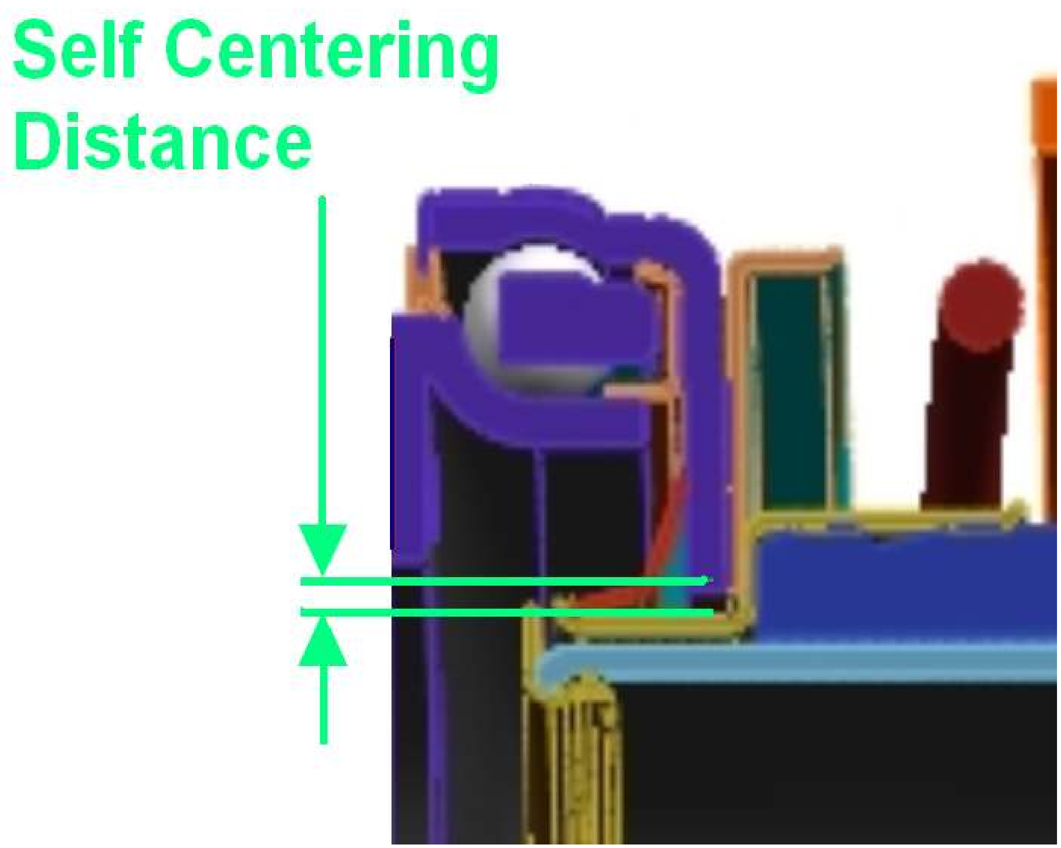


Outer Rotating "Donut" Bearing: Bearing contact surface is flat for round clutch fingers. Easy of manufacturability.

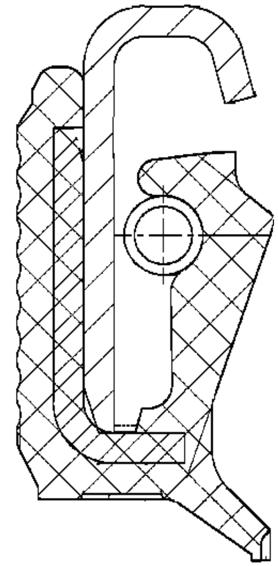
Flat clutch finger contact surface on outer Rotating Race



Release bearings have an integrated a self centering feature to account for the alignment of the transmission to engine/flywheel/clutch area. The bearing moves laterally at a specific axial force to adjust.



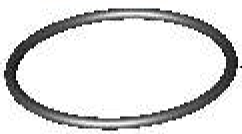
Input shaft seals are usually used in applications where packaging is critical and the free area in the CSC can be used to contain this component.



Seal

ACM

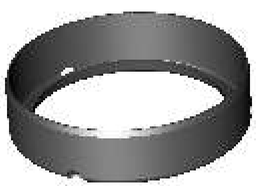
Mineral oil compatible



Spring

Steel

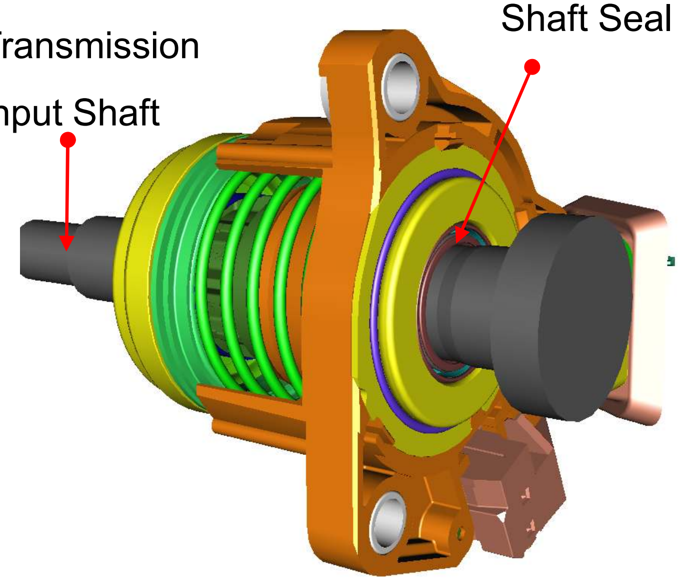
Energizes the shaft seal to keep constant contact with the transmission input shaft



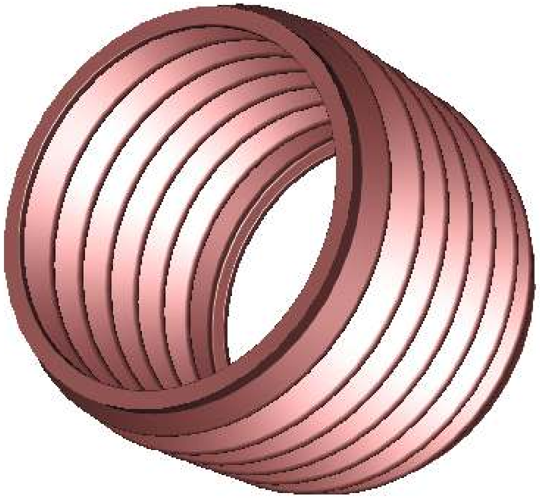
Insert

Steel

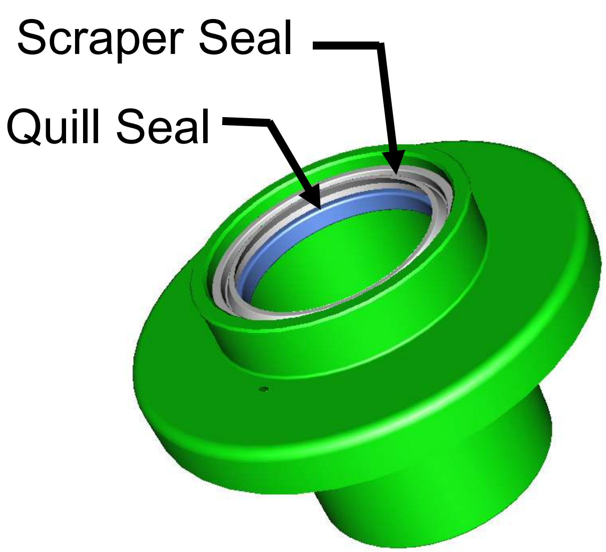
Stabilizes (structure) shaft seal



Contamination Resistance for CSC Designs



Convoluted boots are used in applications with vented bell housings to protect from dirt and dust



An additional scraper seal and id quill seal are used especially with plastic csc's to protect from dirt and dust. (vented transmission housings)

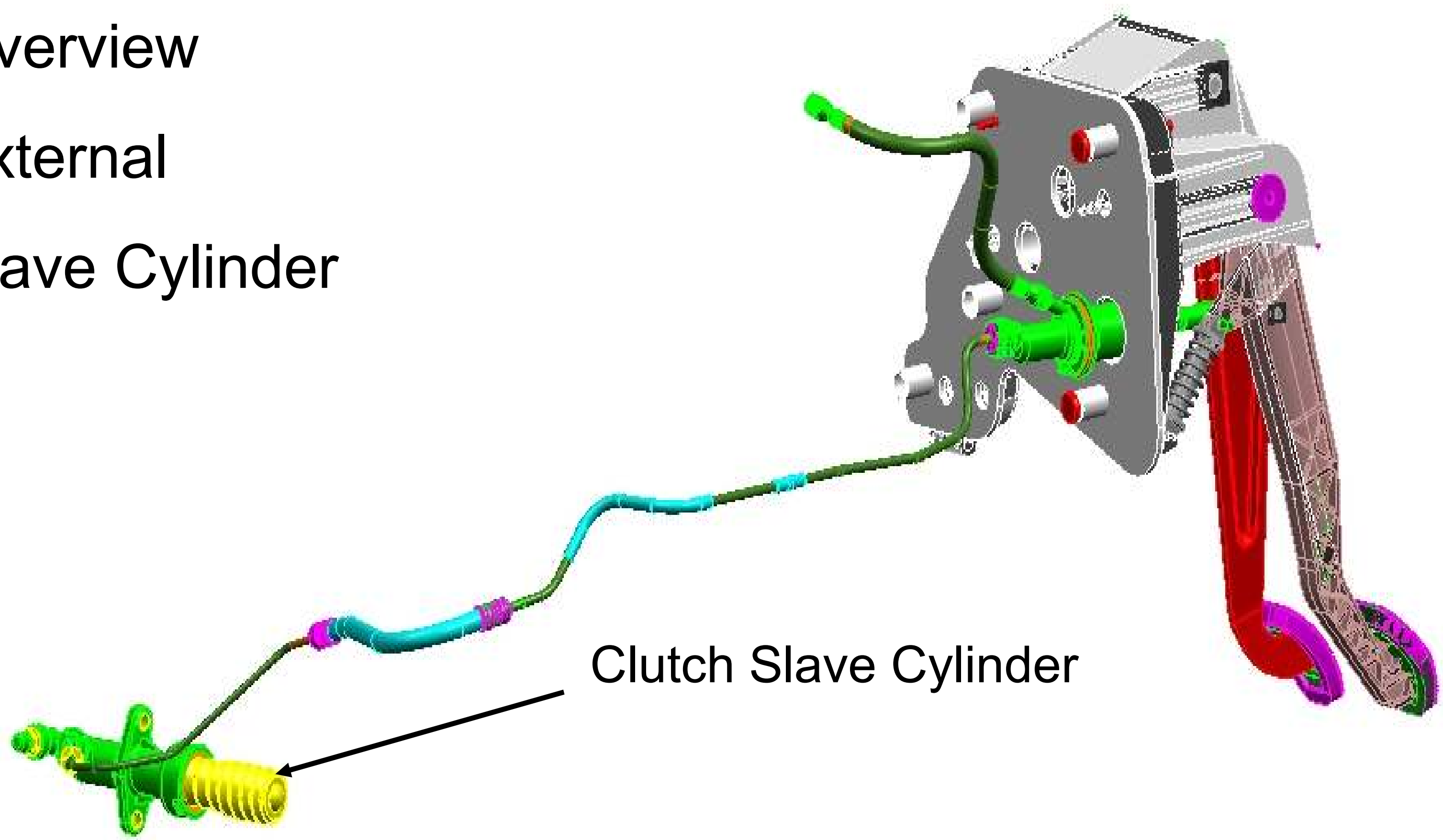
(especially for truck applications)

FTE Hydraulic Clutch Actuation Basics

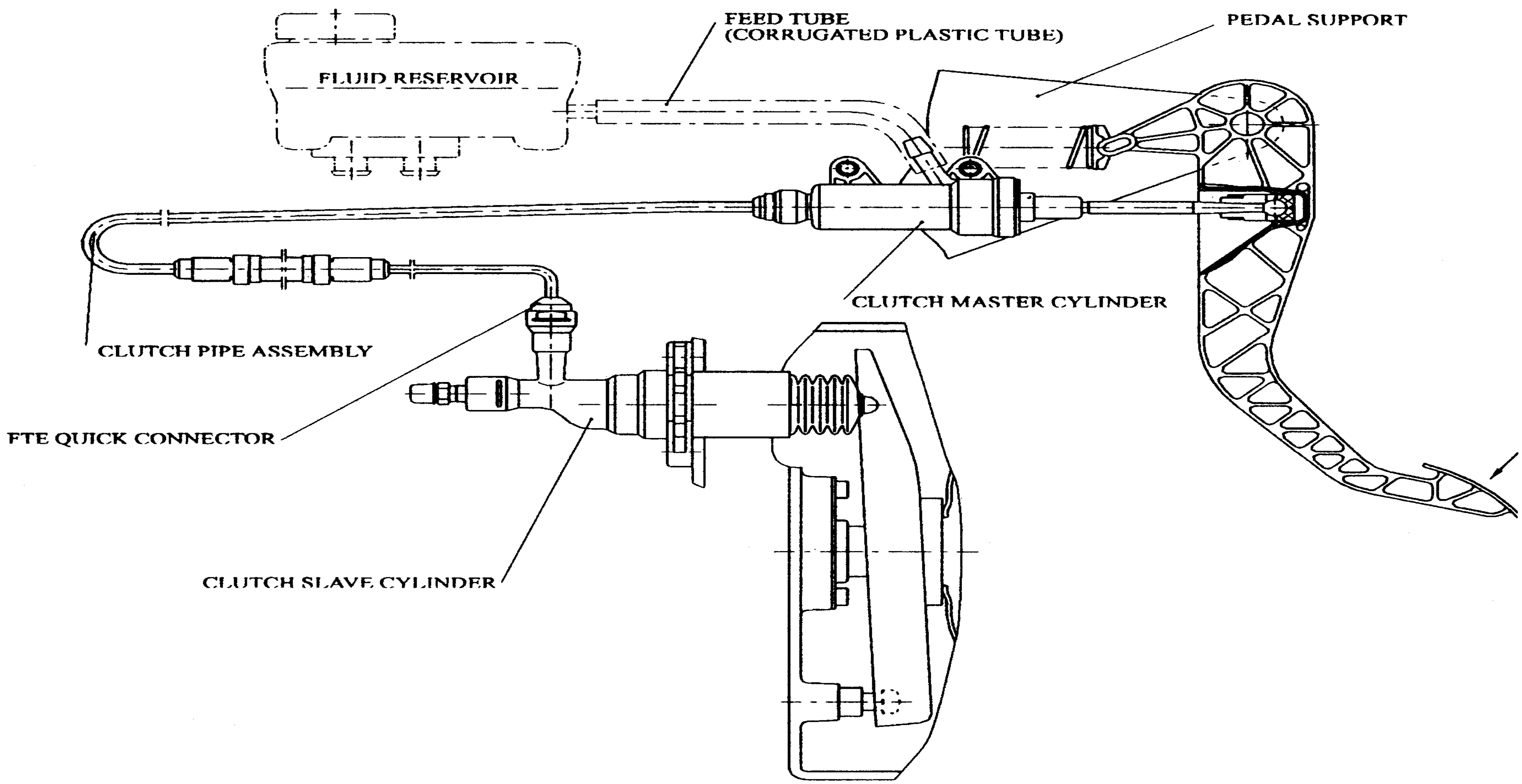
Overview

External

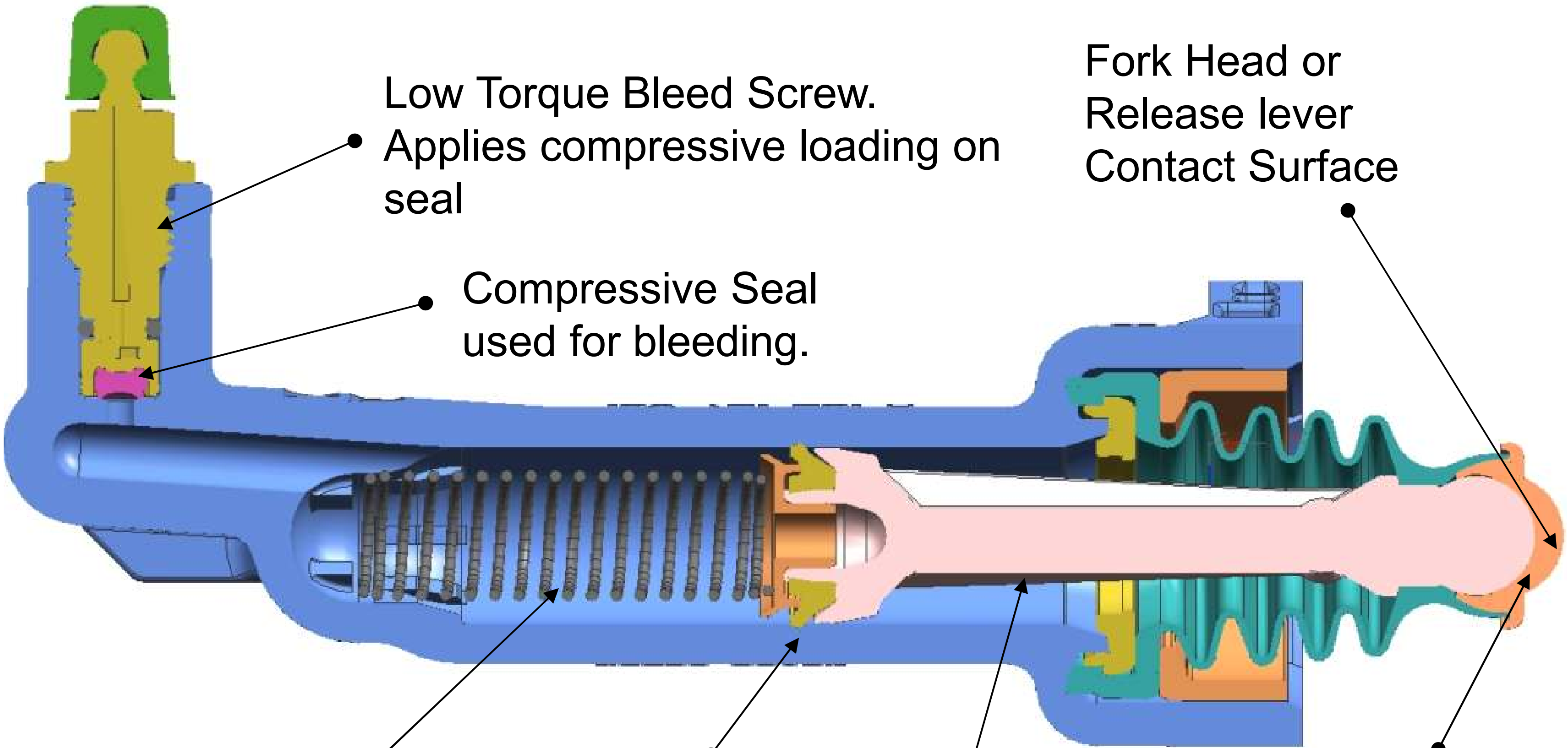
Slave Cylinder



External Slave Cylinder - FTE Hydraulic Clutch Actuation Basics



FTE automotive



➢Housing : Fully plastic or metalic

➢Weight optimized. Non corrosive

➢Quick connector (dry or wet)

➢Twist style bleeder or low torque bleeder availible

➢Preload spring for constant bearing to clutch finger contact

➢PTL can be integrated into pressure port

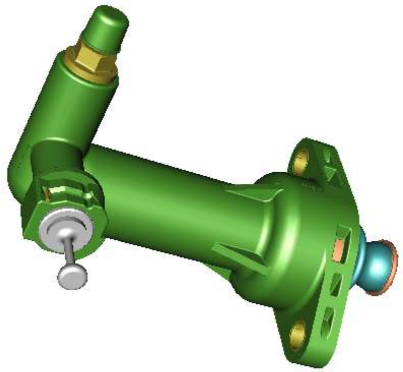
➢Convoluted boot for contamination protection.

Attachment types:

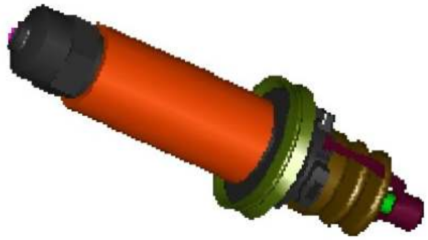
Bushing Bolt

on Flange

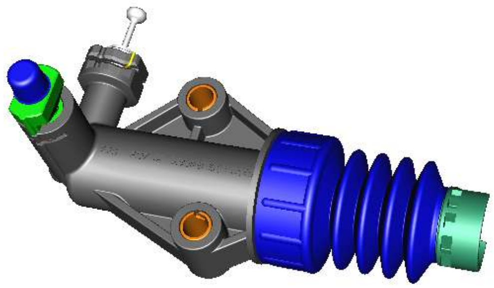
(Compression limiter)

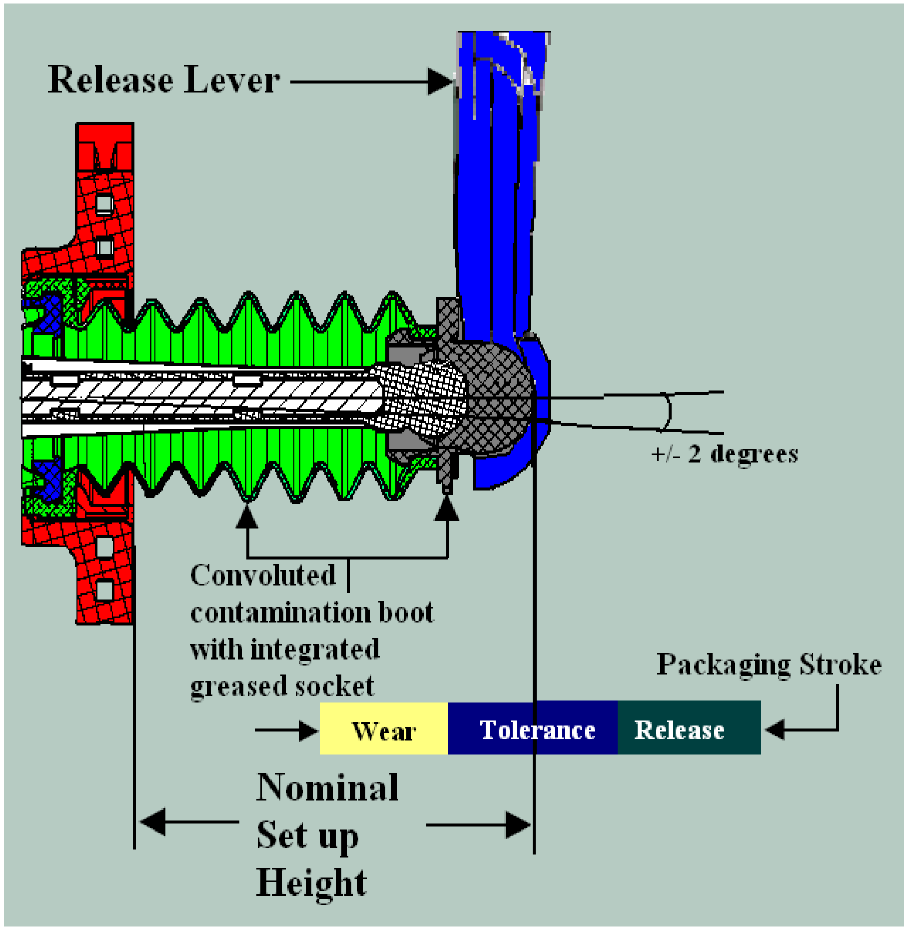


Bayonette



Side Saddle

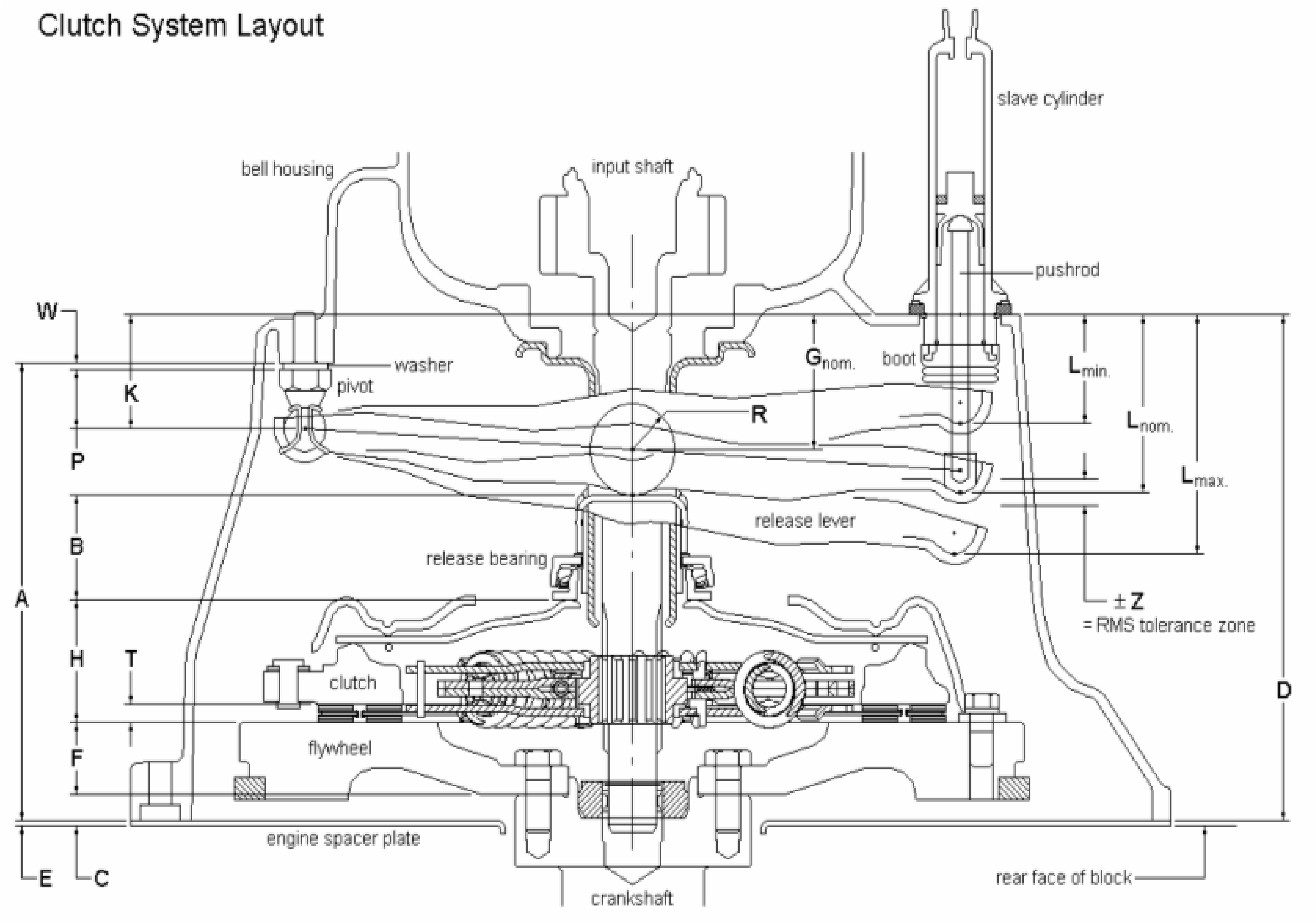




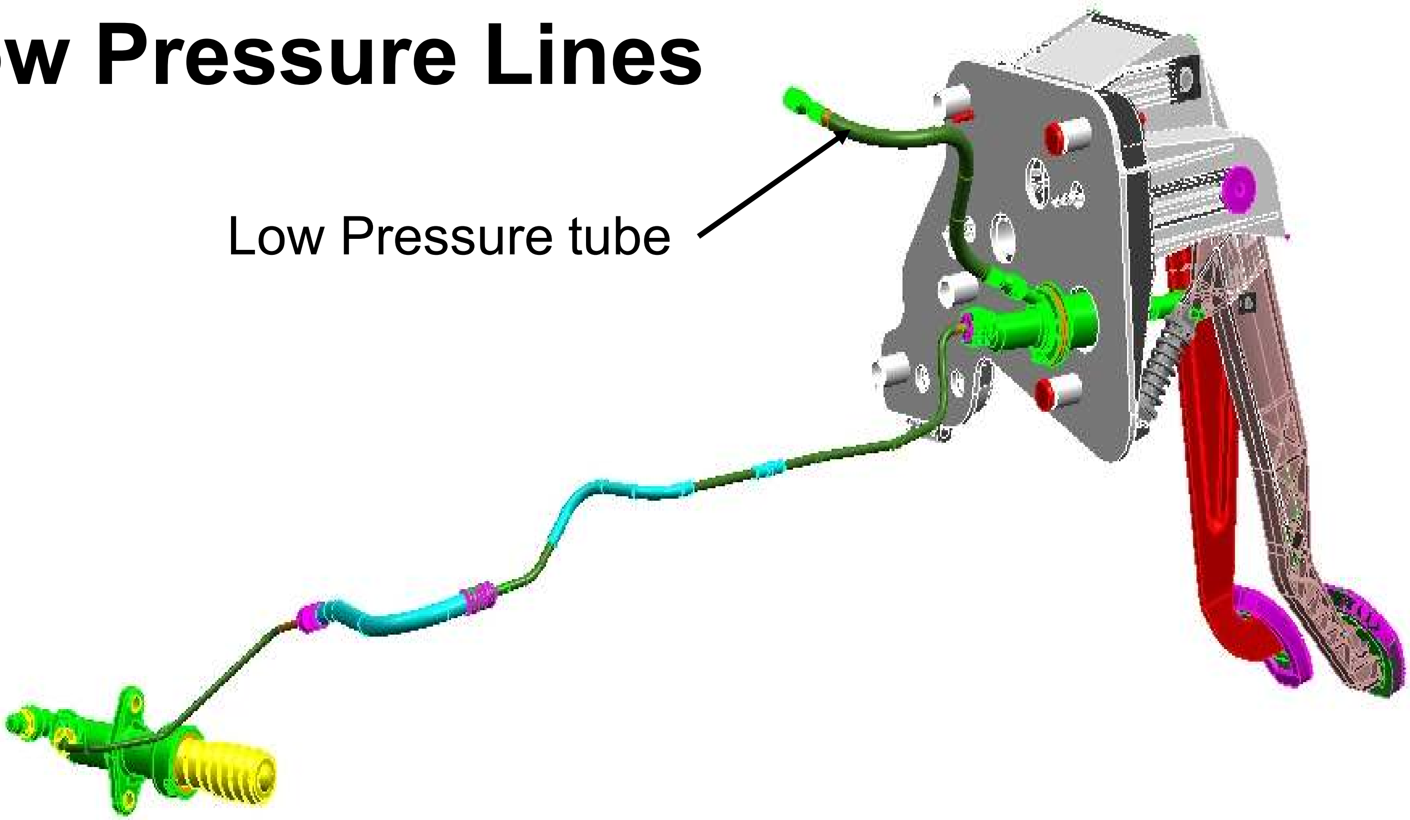
- Bleeder valve must be 0 degrees to pointed upward .
- Mounting face/ slave cylinder bore should be angled upward 2 degrees to facilitate self bleeding.
- S/C stroke must be packaged for wear, release stroke, and tolerances
- S/C pushrod angle not to exceed +/- 2 degrees through full packaging stroke.
- Determining release lever installed height with tolerance, clutch wear travel, and accounting for release travel are necessary to package stroke correctly.

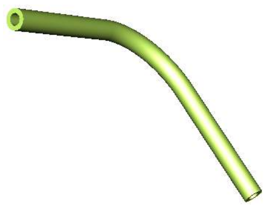
External Slave Cylinder Packaging Considerations

FTE automotive



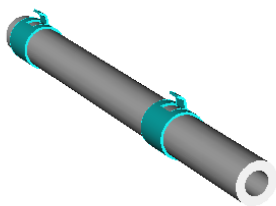
OVERVIEW
Low Pressure Lines





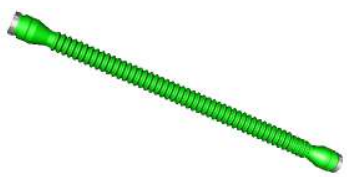
Un-reinforced low pressure EPDM supply line

- Can be used for pre-filled systems
- Holds fill pressure up to 50 PSI (3.4 Bar)
- No Clamps are required with double barb retention design.
- Can be preformed to hold bend shape for close packaging
- Operating temperature range -40 °C to 120 ° C



Reinforced pressure EPDM supply line

- Can be used for pre-filled systems
- Holds fill pressure up to 150 PSI (10.5 Bar)
- Clamps are required at high fill pressure.
- Can be preformed to hold bend shape for close packaging
- Operating temperature range -40 °C to 120 ° C
- Availible also w/ Low pressure quick connect.
- Plastic angle fitting allows easy plant assembly and tight bends from the cmc



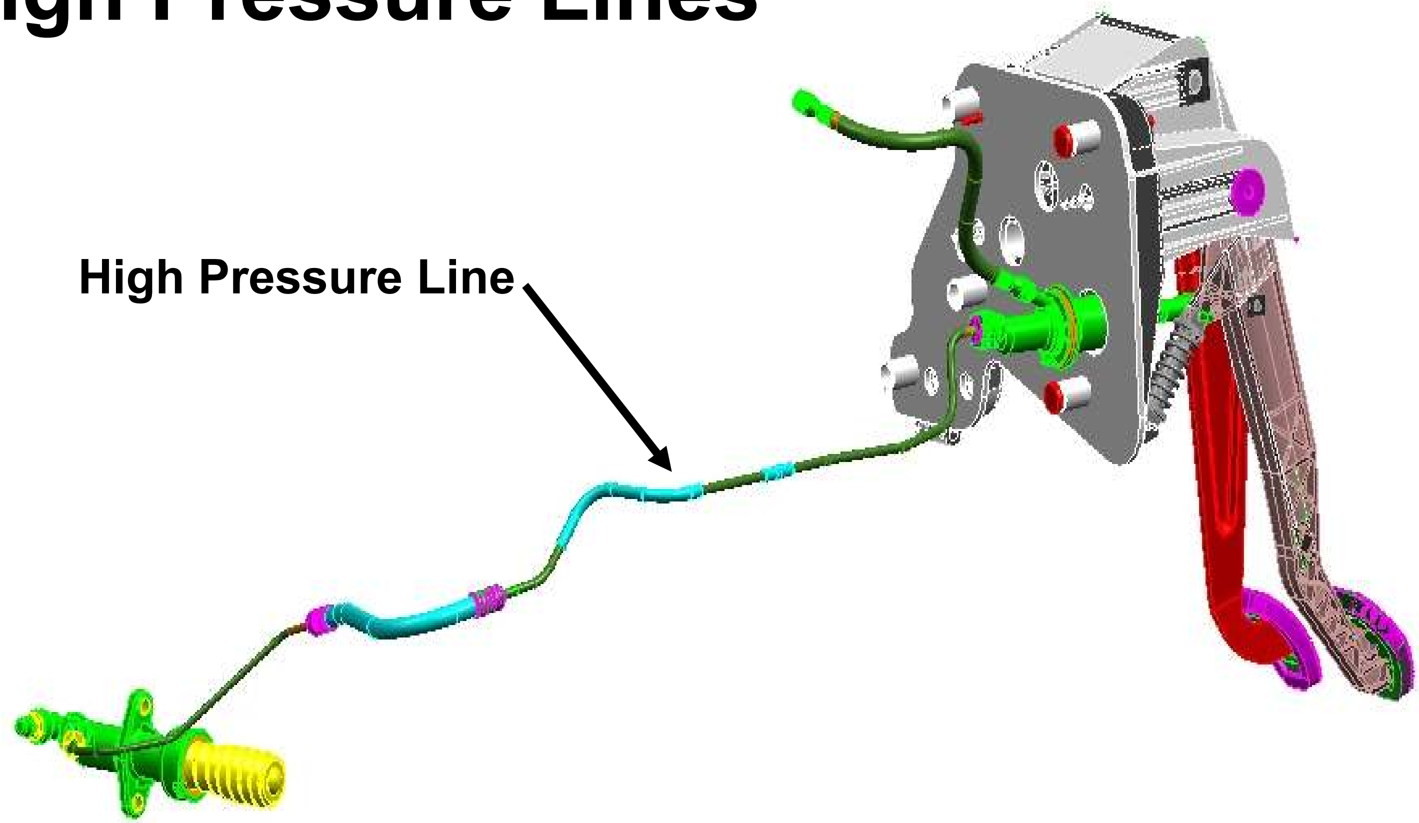
Flexible PP tubes

- Cost Effective and consistent insertion efforts with no tools required
- Holds fill pressure up to 94 PSI (6.5 Bar)
- Can be preformed to hold bend shape for close packaging
- Operating temperature range -40 °C to 120 ° C

Plastic (PA12) Plane feeder tube

- Unique solutions RT angle fitting
- Holds Fill pressure up to 150 PSI (10.5 Bar)
- Formed to hold shape with closer tolerances
- Operating temperature range -40 °C to 120 ° C

OVERVIEW
High Pressure Lines

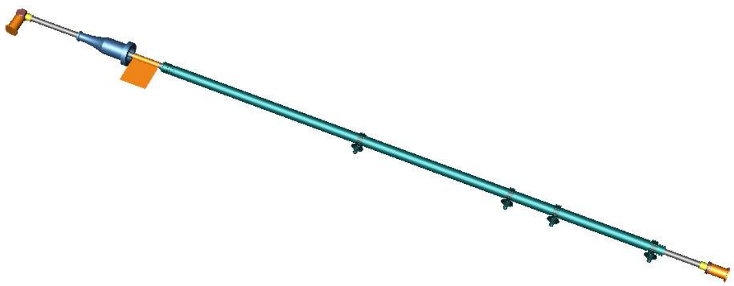


Nylon 12, Nylon 6-12, or Nylon 6-10

Tube

- Pre-formed to meet vehicle routing requirements
- Compensates for engine roll
- Operating temperature ranges -40 to 120 C
- Peak Temperature depending on application, shielding and system pressure.

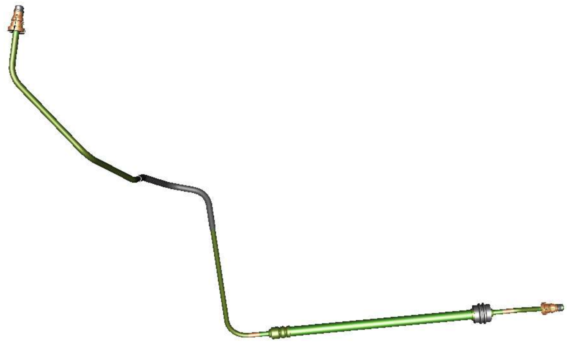
PTFE-Stainless Steel Braided Tube



- No forming required.
- Compensates for engine roll
- Operating temperature ranges -40 to 170 C+
- High Burst Strength

Steel tube

(with flexible engine roll member required)



- Pre-formed to meet vehicle routing requirements
- High Burst Strength
- Operating temperature ranges -40 to 150 C

Pressure Pipe Basic Packaging Considerations:

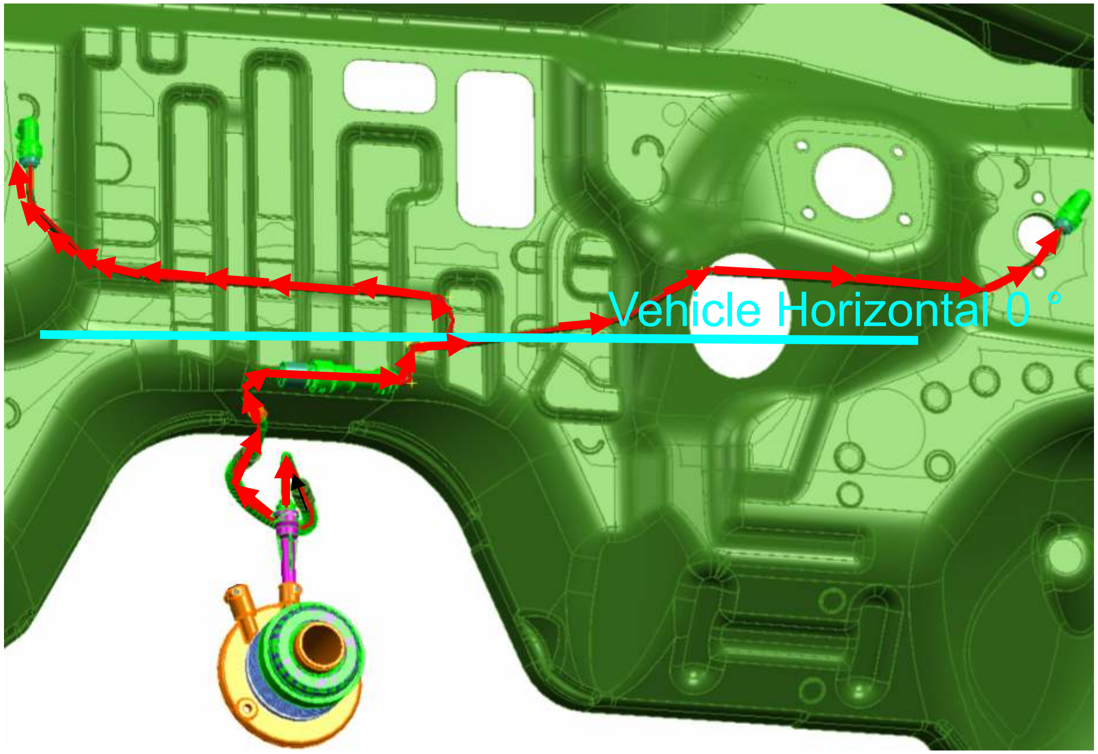
Pressure Tube

- Must have upward routing, no siphon. High point dip on the line must be less than 30% of the displaced volume.
- Routing should be designed at least 100 mm from the heat source when possible.
- Rigid tubes must be secured to prevent side loading pressure connections.

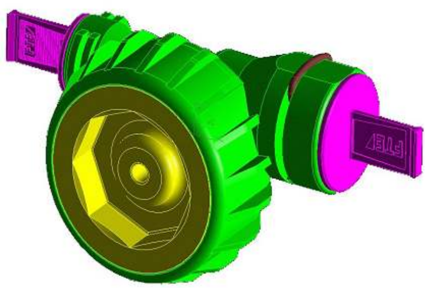
Additional Tube Features

(Temperature and Abrasion Resistance)

- Heat Sleeves
- Isolators
- Convoluted Conduit
- Tube and Conduit Clips



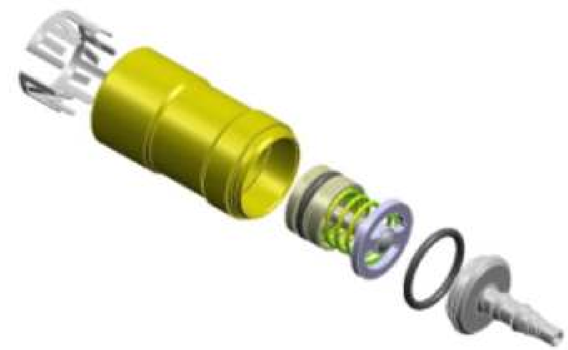
Additional Enhancements



Quick Connects, Dampers, and Peak Torque Limiters

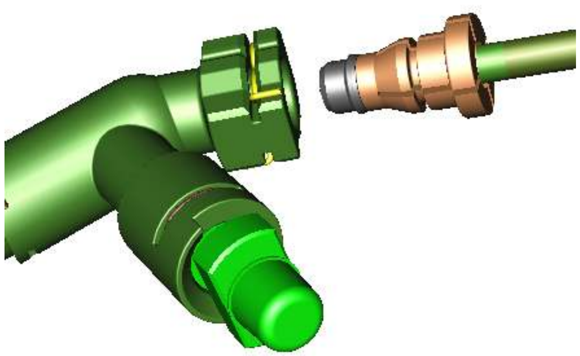
Wet Quick Connects

- Allows for modular pre-filled assembly/service
- Simplifies assembly at the vehicle plant

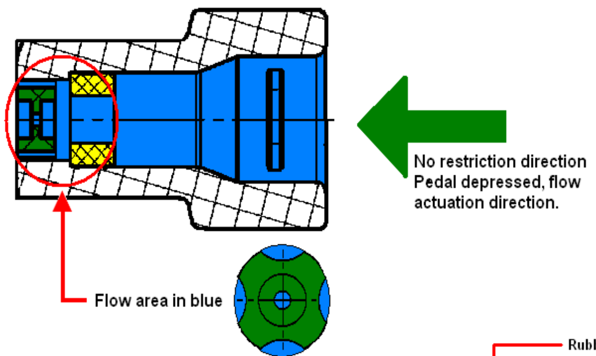


Dry Quick Connects

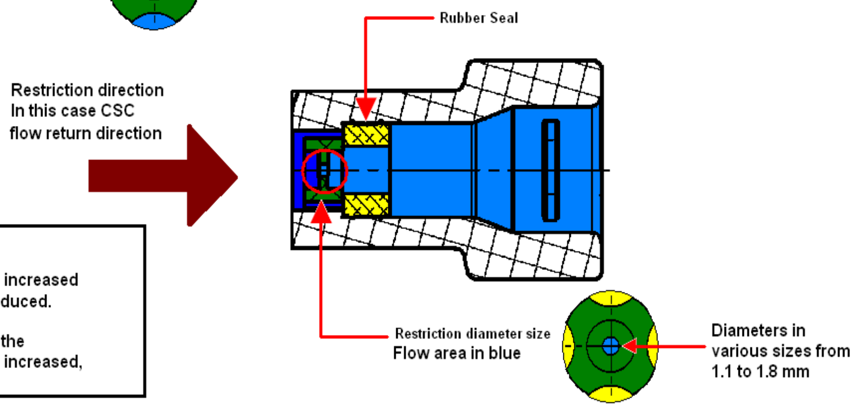
- Allows for modular dry assembly with out tools
- Free rotating connector fittings
- Simplifies assembly at vehicle plant



Peak Torque Limiters (PTL) & Restricted Orifice



Advantages:
Able to minimize impact force to driveline without impacting the actuation or depressed direction.



Disadvantage:
Engagement time is increased as temperature is reduced.

Higher hysterisis in the system. Return side increased, apply side is same.

Driveline Shock Valves

- Reduces Driveline Shock during engagement
 or disengagement
- Protects transmission components from damage

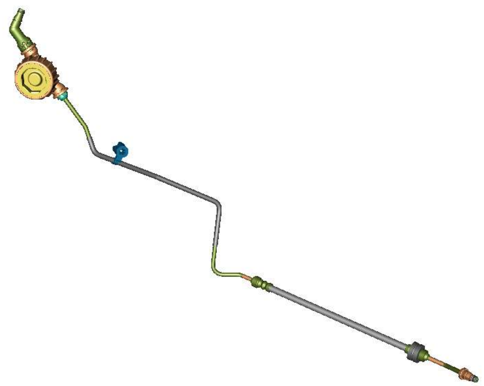
Long, thin pipes (helix or pig tail)

Increase of the vibrating mass. Because of the narrow pipe section, the fluid has apparently a bigger mass. Because of the bigger mass, the eigenfreqency gets lower (most times less than 50 Hz). The actuation system is stimulated postcritically and therefor it stays more calm.

Hard hoses

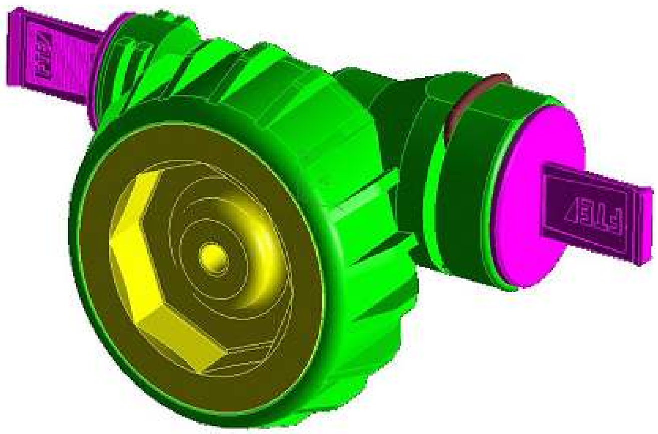
A soft hose (z.B. 02.026) gets into resonance at a length (f.ex. 250 mm) at 100 to 150 Hz, that means vibrations are more reinforced. Hard hoses carry less vibrations just in that critical area. These hard hoses get into resonance at more than 200 Hz.

Additionally hard hoses have a smaller inner diameter



Frequency Modulator (FM) and Stiff hose

Both Plastic and Aluminum Versions. Aluminum version is used where packaging is a concern.



Working principle:

The idea of the frequency modulator (FM) is to create an elasticity to moderate hard hits, but with a geometry which has nearly no dimensions.
So the FM can not get into resonance (or not until much higher frequencies).
Now the hose can be much stiffer, as it does not have to moderate the hits anymore. In this way, the additional volumetric absorption of the FM can be compensated.

Vibrations stop (inline damper)

Working principle:

Two spring charged valves, which open at a differntial pressure of about 1 bar, one for disengaging, one for engaging pressure vibrations, which are smaller than this opening pressure are nearly completely blocked at a stationary pedal. During the actuation of the pedal, the fluid column is connected and vibrations can be carried. For this case, the rubber inside functions like a small FM.

Positives: Reduction of pedal vibrations at

- Pedal actuated (e.g. waiting before traffic light)
- Foot on pedal (e.g. during frequently gear switching)
- Pedal actuated (dynamic)

Reduction of noises

Lean design >packaging optimized

Negatives: Increase of hysteresis because opening pressure
(e.g. 3 N at pedal at CMC Ø 15 & Ped = 5)

● May Occur

Clutch Control System
DIAGNOSTIC CHART

Complaint / Condition \ Cause	Improper Pedal Travel	Clutch Pedal Bent	Clutch Disc Faulty	Clutch Disc Hub Binding	Clutch Disc Warped or Bent	Pressure Plate to Flywheel Bolts Loose	Air in Hydraulic System	Owner Operation Improper	Oil Soaked Clutch Disc	Clutch Facing Torn from Disc	Pressure Plate or Flywheel Warped	Clutch Facing Not Seated In	Clutch Facing Burnt or Glazed
Clutch Fails to Release	●	●	●	●	●	●	●						
Clutch Slips						●		●	●	●	●	●	●
Clutch Grabs or Chatters				●		●			●		●	●	●
Transmission Noise/Clutch Disengaged													
Transmission Noise/Clutch Engaged													
Transmission Gear Rattle													
Low or No Pedal Effort							●						
High Pedal Effort (Hard Pedal)		●											
Clutch Pedal Spongy							●						
Clutch Pedal Binds/Shudders													
Clutch Pedal Squeak		●											
Clutch Pedal Buzz/Growl		●								●			
Hard to Shift	●	●	●		●	●	●	●					
Clutch Pedal Sticks		●											
Leaks	●												
S/C Blow Out	●												

Complaint / Condition \ Cause	Input Shaft Splines Worn or Damaged	Oil in Clutch Disc Damper	Clutch Disc Damper Failure	Engine Idle Speed Low	Release Bearing Binding	Release Bearing Faulty	Hydraulic System Failure	Clutch Facing Worn	Pedal Bushings Worn	Pressure Plate Faulty or Damaged	Engine Miss Fire	Faulty Pilot Bearing	M/C Bypassing (Internal Leak)
Clutch Fails to Release	●		●		●		●			●		●	●
Clutch Slips							●	●		●			
Clutch Grabs or Chatters	●					●				●	●		
Transmission Noise/Clutch Disengaged					●	●	●					●	
Transmission Noise/Clutch Engaged					●	●	●						
Transmission Gear Rattle		●	●	●									
Low or No Pedal Effort							●						
High Pedal Effort (Hard Pedal)					●		●	●	●	●			
Clutch Pedal Spongy							●						
Clutch Pedal Binds/Shudders					●		●		●				
Clutch Pedal Squeak							●		●				
Clutch Pedal Buzz/Growl									●				
Hard to Shift	●				●		●			●		●	●
Clutch Pedal Sticks							●						
Leaks							●						
S/C Blow Out													

Complaint / Condition \ Cause	CSC Leak (External)	M/C Leak (External)	Engine Rear Main Seal Leak	Transmission Input Shaft Seal Leak	Clutch Eek, Finger Contact Squeak	Pedal Hang-up on Carpet	Improper Hydraulic System Fluid Added	Transmission Synchronizers Damaged or Faulty	Clutch not Properly Adjusted (SAC)	Bind in Hydraulic Cylinder	Worn Gear Box Front Bearing	Bent Release Lever	Release Lever Bind
Clutch Fails to Release	●	●					●					●	
Clutch Slips			●	●									●
Clutch Grabs or Chatters													
Transmission Noise/Clutch Disengaged													
Transmission Noise/Clutch Engaged											●		
Transmission Gear Rattle													
Low or No Pedal Effort									●				
High Pedal Effort (Hard Pedal)			●	●			●			●		●	●
Clutch Pedal Spongy		●							●				
Clutch Pedal Binds/Shudders			●	●			●						●
Clutch Pedal Squeak					●								
Clutch Pedal Buzz/Growl													
Hard to Shift		●						●				●	●
Clutch Pedal Sticks						●	●		●	●			
Leaks	●	●	●	●									
S/C Blow Out													

Complaint / Condition \ Cause	Pivot not Lubed or Worn	Release Bearing/Release Lever Interface	Fork Stabilizer Missing (if fitted)	S/C P-Rod not Seated in Release Lever Pocket	S/C Contamination (External)	Misalignment S/C P-Rod	Release Bearing Misalignment	Improperly Installed S/C	Worn Engine/Transmission Mount	Shift Forks in Trans. Damaged or have Burrs	Clutch Diaphragm Spring Broken	Floor Mat or Carpet too Thick	Bleed Screw Loose
Clutch Fails to Release												●	●
Clutch Slips							●						
Clutch Grabs or Chatters													
Transmission Noise/Clutch Disengaged													
Transmission Noise/Clutch Engaged			●										
Transmission Gear Rattle													
Low or No Pedal Effort											●		
High Pedal Effort (Hard Pedal)	●			●			●				●		
Clutch Pedal Spongy													
Clutch Pedal Binds/Shudders	●						●		●				
Clutch Pedal Squeak		●					●						
Clutch Pedal Buzz/Growl													
Hard to Shift				●						●			
Clutch Pedal Sticks												●	
Leaks					●	●							●
S/C Blow Out				●				●					