Oil Hydraulics and Pneumatics
Prof. Somashekhar S
Department of Mechanical Engineering
Indian Institute of Technology, Madras

Part 1: Introduction, Constructional details of cylinders, Seals and types,
Lecture - 51
Hydraulic Cylinders

My name is Somashekhar, course faculty for this course.

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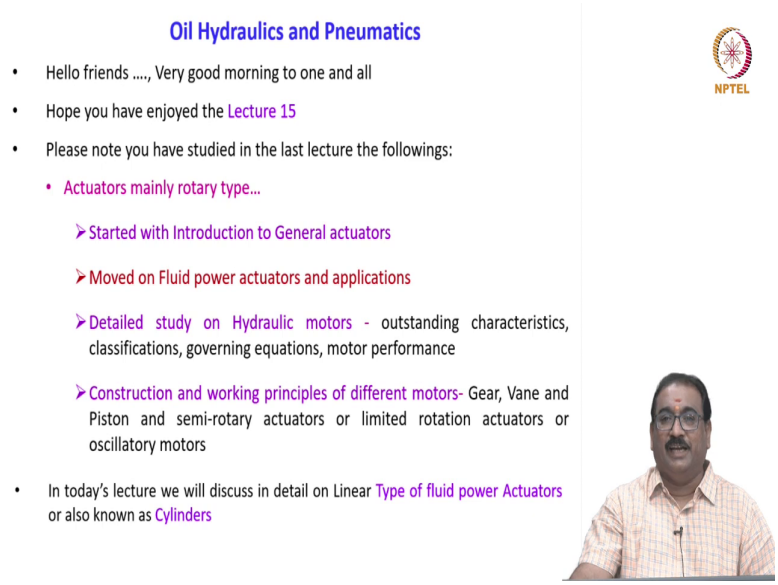

Hello friends, very good morning to one and all. Hope you have enjoyed the lecture 15. Please note you have studied in the last lecture the followings: actuators mainly rotary type. Here we started our lecture with introduction to general actuators, moved on to fluid power

actuators and applications, detailed study on hydraulic motors, outstanding characteristics, classifications, governing equations and motor performance.

Later we discussed constructional details and working principles of different motors gear type, vane type, piston type and semi rotary actuators, these are also known as limited rotation actuators or oscillatory motors. In today's lecture we will discuss in detail a linear type of actuators they are also known as cylinders.

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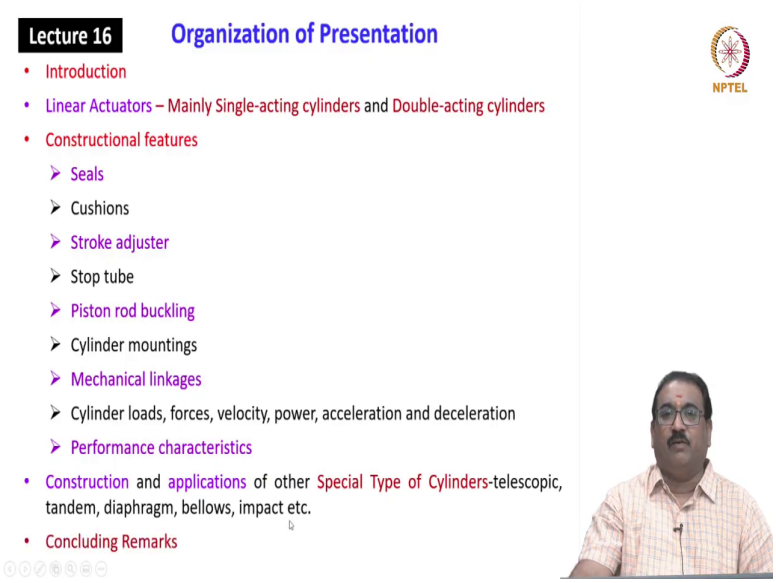

This is the organization of presentation start with introduction. Linear actuators mainly single acting cylinders and double acting cylinders. Constructional features which covers: seals, cushions, stroke adjuster, stop tube, piston rod buckling, cylinder mountings, mechanical linkages, cylinder loads, forces, velocity, power, acceleration and deceleration of the cylinders. Performance characteristics mainly the efficiency characteristics and functions.

Construction and application of other special type of cylinders are also covers mainly the telescopic cylinders, tandem cylinders, diaphragm cylinders, bellows and impact cylinders etcetera. Finally, I will conclude this lecture.

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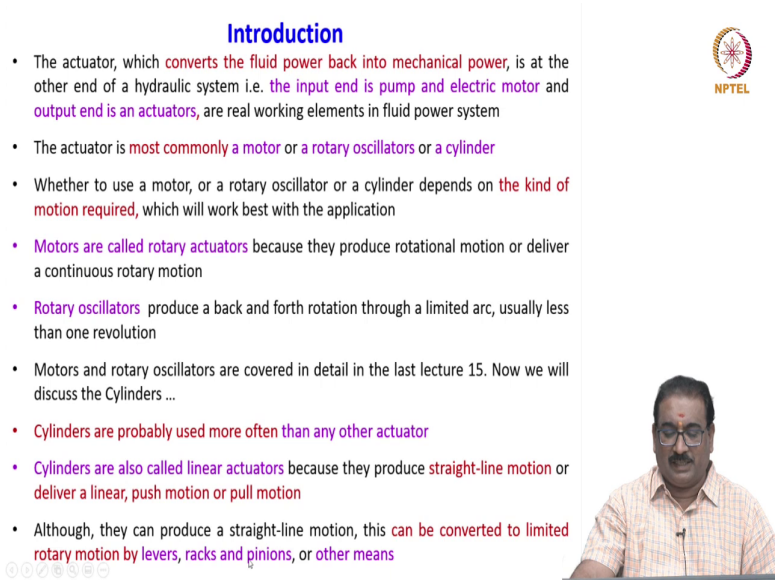

The actuators, which convert the fluid power back into mechanical power, is at the other end of the hydraulic system that is the input end is a pump and electric motor and output end is actuators, they are real working elements in the fluid power system. The actuator is most commonly a motor or rotary oscillator or a cylinder. Whether to use a motor or a rotary oscillator or a cylinder depends on the kind of motion required, which will work best with applications.

Motors are called rotary actuators because they produce a rotational motion or deliver a continuous rotary motion. Rotary oscillators on other hand produce a back and forth rotation

through a limited arc, usually less than one revolution. Friends, motors and oscillators are covered in detail in the last lecture 15.

Now, we will discuss mainly the cylinders. Cylinders are probably used more often than any other actuators. Cylinders are also called linear actuators because they produce a straight line motion or deliver a linear, push motion or a pull motion. Although, they can produce a straight line motion, this can be converted to limited rotary motion by levers, racks and pinions, or other means.

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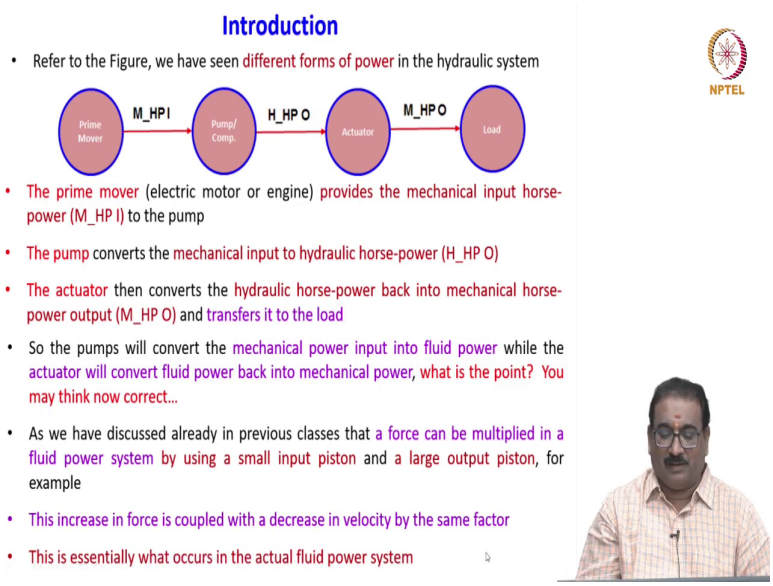

Referring to this figure, we have seen different forms of power in the hydraulic system and pneumatic system also. Here you will see the first one I have drawn the prime mover, the next circle represents the pump or compressor, next one is an actuator, which is used to drive the

loads. The prime mover basically the electric motor or a IC engine provides the mechanical input power to the pump or a compressor.

The pump or a compressor converts the mechanical input power to hydraulic horse power. The actuator then converts the hydraulic horse power back into the mechanical horse power output and transfer it to the load. So, the pump converts the mechanical power into fluid power while the actuator will convert the fluid power back into the mechanical power, what is the point? You may think now correct.

As we have discussed already in the previous classes that in a fluid power system by using a small input piston and a large output piston, for example. Meaning you are seen in the last class, how the multiplication of forces takes place, how the pressure intensification takes place by changing the geometry. This increase in force is coupled with a decrease in velocity by the same factor. This is essentially what occurs in the actual fluid power system.

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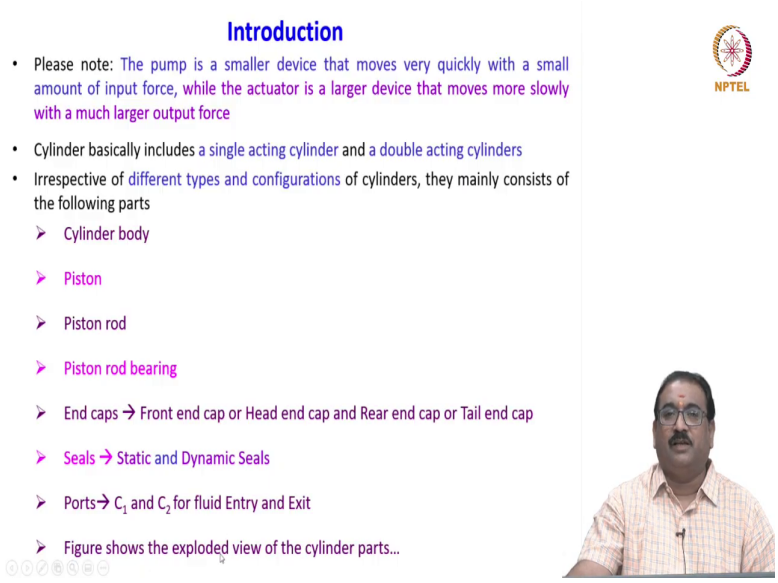

Please note friend the pump is a smaller device that moves very quickly with a small amount of input force, while the actuator is a larger device that moves more slowly with a much larger output force.

Cylinder basically includes a single acting cylinder and double acting cylinders. Irrespective of different types of configurations of the cylinders, they mainly consists of the following parts; cylinder body, piston, piston rod, piston rod bearings, end caps front end cap are also known as head end cap and a rear end cap or a tail end cap.

Then various types of seals, the static as well as dynamic seals are used in the constructional future. Ports are there C 1 and C 2 for fluid entry and exit in some books you will get A and B. The figure shows the exploded view of the simple cylinder parts.

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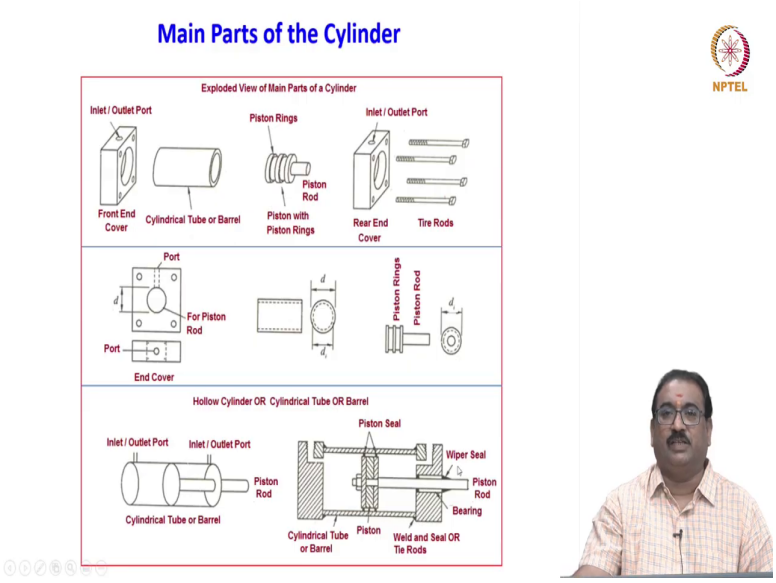

These are the main parts as I have shown you in the previous slide, you will see here front end cover which carries the inlet outlet port and cylindrical tube also known as a barrel. This is a piston with piston rings.

This is the piston rods, then rod and cover again it carries the inlet outlet ports, the tire rods for tight connection of these parts. You will see here friends end cover carries the port, here you will see the diameter of the port openings. Here it is a barrel; this is the bore diameter d what I have shown you here.

Here the piston rings, piston rod, again the piston rod is having the diameter. Piston diameter and piston rod diameters are very very important during the calculation of the effective areas, over which the pressure is acting. Here you will see the hollow cylinder as I have told you

inlet outlet port; inlet outlet port cylinder tube or a barrel; it is a piston rod which carries the load.

Here the sectional views I have shown you, here the inlet outlet port; inlet outlet port, it is a piston, piston seals are there here, then it is a piston rod, also there are various types of seals are there we will discuss in today's class.

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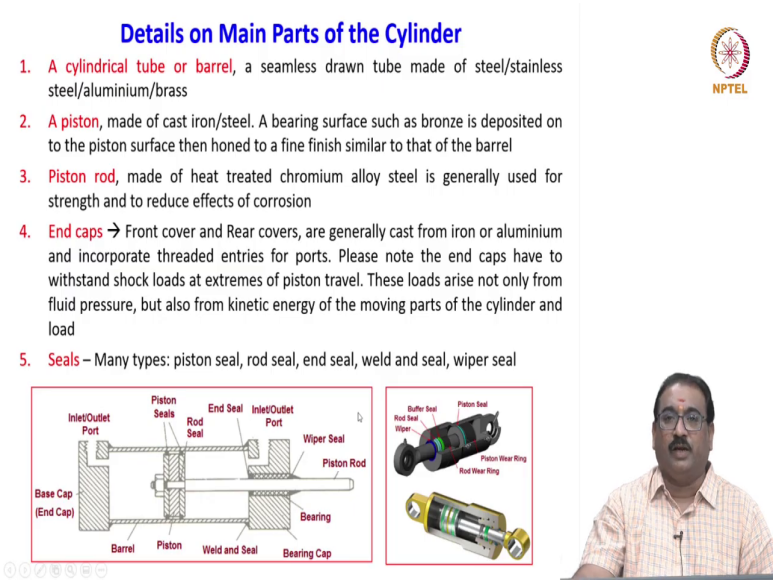

I will quickly I will give you the details of each part. A cylindrical tube or a barrel, seamless drawn tube made of steel or stainless steel or a aluminium or a brass. A piston, made of cast iron or a steel. A bearing surface such as bronze is deposited on to the piston surface then honed to a fine finish similar to that of the barrel because piston is moving inside the barrel, inside barrel and outside the piston there the honed surface.

The piston rod, made of heat treated chromium alloy steel is generally used for strength and to reduce a effects of corrosion. End caps front cover and rear covers, are generally. The cast from iron or aluminium and incorporated threaded entries for a ports. Please note the end caps have to withstand shock loads at a extremes of piston travel.

These loads arise not only from the fluid pressure, but also from kinetic energy of the moving parts of the cylinder and a load. Fifth one is seals mainly to reduce the leakage. The main types are: piston seal, rod seal, end seal, weld and seal and wiper seals and much more. Here you will see friends this is a barrel, this is a end covers, end caps it is, base cap and a bearing cap here.

The inlet outlet ports are there, again you will see the piston seals are there, then rod seals are there here, then you will see here the weld seals and when the piston rod comes out of the bearing cap there are the wiper seals are there, correct. Many seals are you are seen here, you will see in the this figure also there are various types of seals, we will discuss these things also in today's class.

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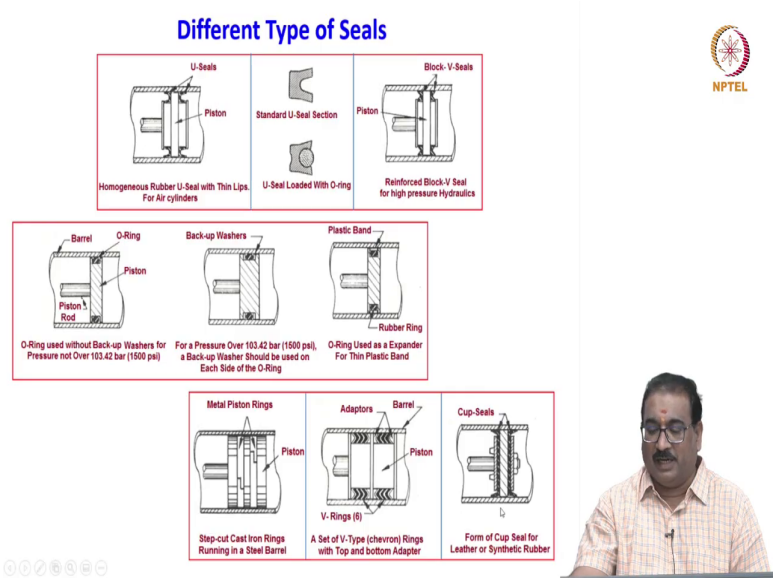

As I have told you different types of seals are there commercially. You will see here this is a barrel and a piston, here I have shown you the U type seals it is a homogenous rubber U seal with a thin lips for air cylinders.

The standard U seal section how it is there you will see, here the U seal loaded with the O ring. Here you will see the block V seals 2 side, you will see top and bottom correct for the high pressure hydraulics it is. See some more seals here what I have seen you here O ring seals, the O ring seal used without backup washers for a pressure not over 103.42 bar. Here you will see with washer they are using here over 103.42 bars. A backup washer should be based on the end side of the O ring.

Here you will see friends again, the O ring used as an expander for a thin plastic band, again you will see some more seals, here you will see the metal piston rings. Here step cut cast iron

rings running in a steel barrel, here you will see friends a set of V type rings with a top and bottom adapters. Here you will see the cup seals, the cup seal for a leather or a synthetic rubber it is.

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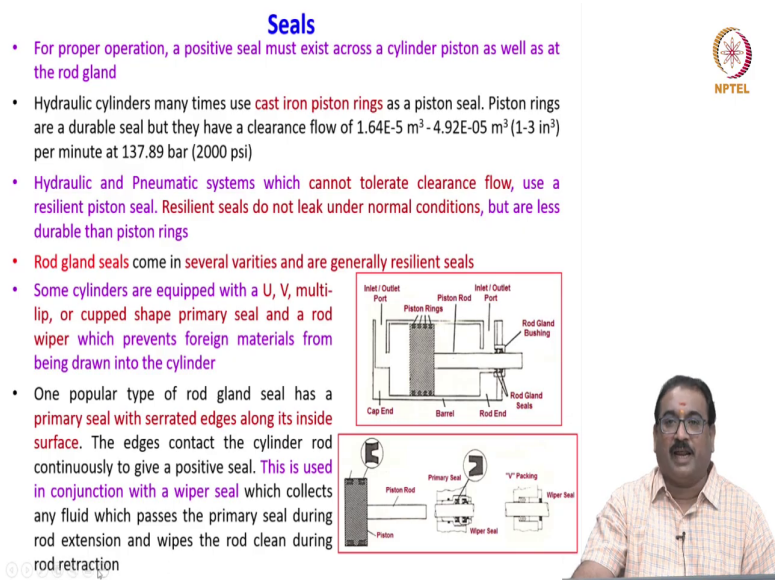

For proper operation, a positive seal must exist across a cylinder piston as well as at the rod gland. You will see here friends here it is a barrel inlet and outlet port; inlet and outlet port, piston rod.

Here please see here the piston rings are there here and here you will see the rod gland bushing here and then also inside rod gland seals. Here I have shown you the U type of seals and U type of seal with serrated shape which is used to make the positive seal with the rod, it is used along with the wiper seal. Also we will see here the V packing with a wiper seals at the end like this combinations they are using to overcome the leakage.

Hydraulic cylinders many times use a cast iron piston rings as a piston seal. Piston rings are durable seal but they have a clearance flow of this much m cube per minute at 137.89 bar. Hydraulic and pneumatic systems which cannot tolerate clearance flow, use a resilient piston seal. Resilient seals do not leak under a normal conditions, but are less durable than piston rings. Rod gland seals you will see here rod gland seals come in several varieties and are generally resilient seals these are.

Some cylinders are equipped with a U, V, multi lip, or a cupped shaped primary seal and a rod wiper which prevents a foreign materials from being drawn into the cylinder. One popular type of rod gland seal has a primary seal with a serregated edges you will see here please closely you will observe, these are the serregated edges along its inside surface.

The edge contact the cylinder rod continuously to give the positive seal. This is used in conjunction with the wiper seal which collects any fluid which passes the primary seal during the rod extension and wipes the rod clean during rod retraction.

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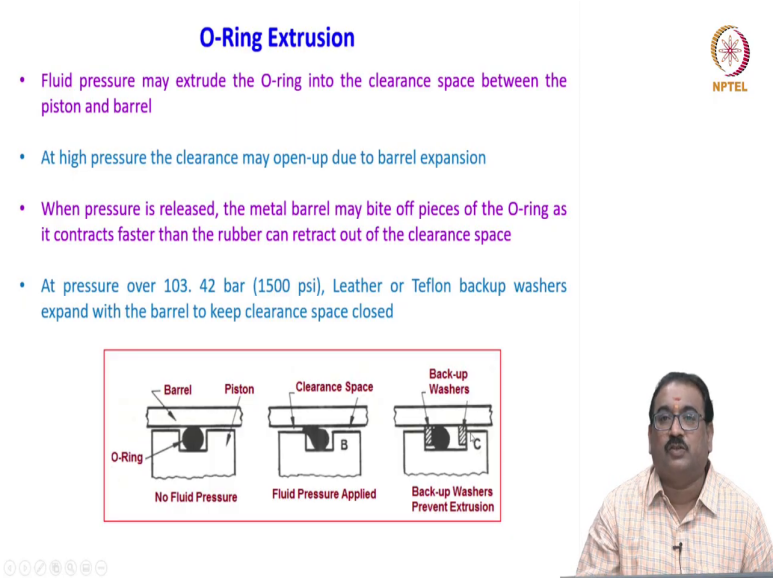

Now, I will show you one more thing the O ring extrusion, the how it happens during the piston travel here. Here fluid pressure may extrude the O ring into the clearance space between the piston and barrel. You will see here this is the barrel surface and this is the piston.

Here it is O ring, here no fluid pressure when fluid pressure will come here what happens? At high pressure the clearance may open up due to barrel expansion. When pressure is released, the metal barrel may bite off pieces of the O ring as it contracts faster than the rubber can retract out of the clearance space.

At a pressure over 103.42 bar, leather or a Teflon backup washers expand with the barrel to keep the clearance space closed. That is why they are using the backup washer along with the O ring, which will prevents the O ring extrusion. This is mainly occurs when you are using

only the O ring between the piston and the barrel. To overcome this, what you will do? The backup washers are also used.

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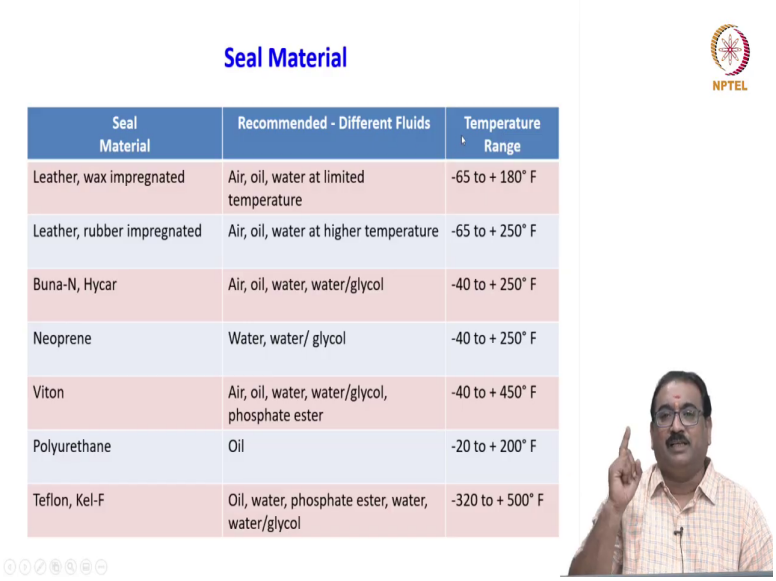

Seal Material	Recommended - Different Fluids	Temperature Range
Leather, wax impregnated	Air, oil, water at limited temperature	-65 to + 180° F
Leather, rubber impregnated	Air, oil, water at higher temperature	-65 to + 250° F
Buna-N, Hycar	Air, oil, water, water/glycol	-40 to + 250° F
Neoprene	Water, water/ glycol	-40 to + 250° F
Viton	Air, oil, water, water/glycol, phosphate ester	-40 to + 450° F
Polyurethane	Oil	-20 to + 200° F
Teflon, Kel-F	Oil, water, phosphate ester, water, water/glycol	-320 to + 500° F

Then you will see friends here, there are different types of seal materials are there started with leather, wax impregnated, leather, rubber impregnated, buna N or hycar, neoprene, viton many materials are there.

Here very careful while selecting the different seal material, it is depending upon the type of fluid used during the operation either a air oil water or water, water glycol based on this you have to select the different seal material. Also you will remember here the last column depicts the temperature ranges these are the 2 important properties to be considered while selecting the seal materials.

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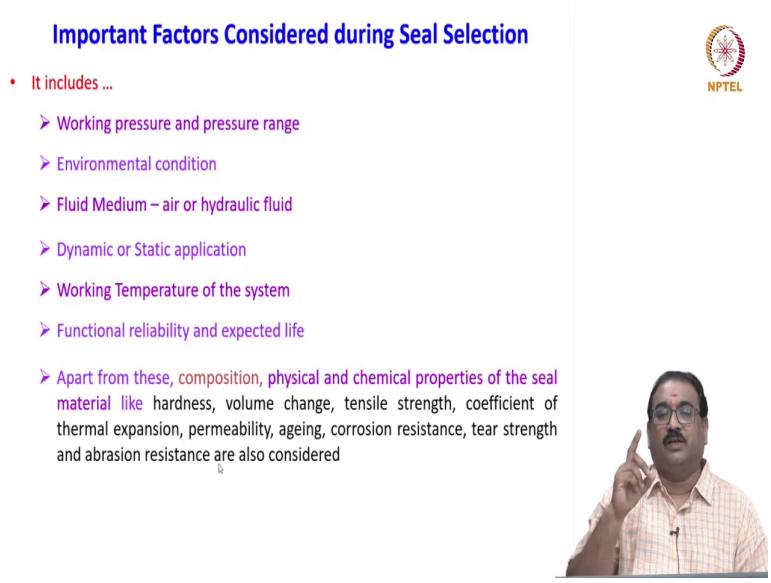

Then I will tell you some more important parameter to be considered while selecting the seals for the particular applications.

What are those? It includes: working pressure and a pressure range, environmental conditions, fluid media whether you are working with air or a hydraulic fluids, as I have told you in the previous slide it depends upon the type of fluid used. And dynamic or a static application, working temperature of the system, functional reliability and a expected life.

Apart from these friends you have to consider the composition, physical and chemical properties of seal materials like hardness, volume change, tensile strength, coefficient of thermal expansion, permeability, ageing, corrosion resistance, tear strength and abrasion resistance are also considered while selecting the seals for the particular applications.