Testing of Functional & Technical Textiles
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Lecture – 17
Testing of Filter Fabrics (contd…)

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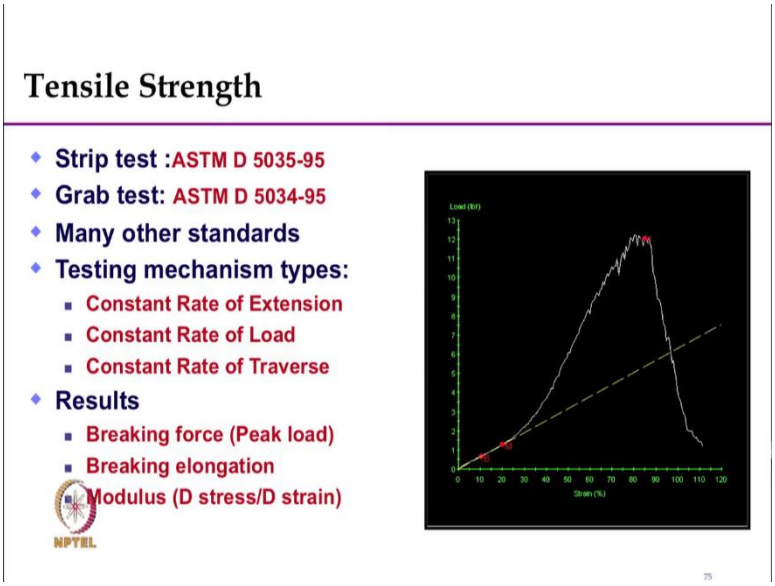

Hello everyone. In today's class, we will discuss the mechanical properties of filter fabrics, and also different standards. We will try to understand different standards, we will also try to understand different types of filters based on their shapes. First mechanical properties, the first mechanical properties which is important for filter fabrics is a tensile strength. Tensile strength can be tested as per strip test, which follows the ASTM D 5035. Grab test, then many other standards also available for this strip test, and grab test.

Testing mechanisms which affect the tensile strength results are there basically gauge length, speeds. So, the mechanisms are constant rate of extension, constant rate of loading, constant rate of traverse. So, we are not going to discuss detail of this methods, because you all must have learned in other course that is evaluation of textile material course. So, here the result is expressed in terms of breaking force is peak load, breaking elongation, and modulus which is stress by strain.

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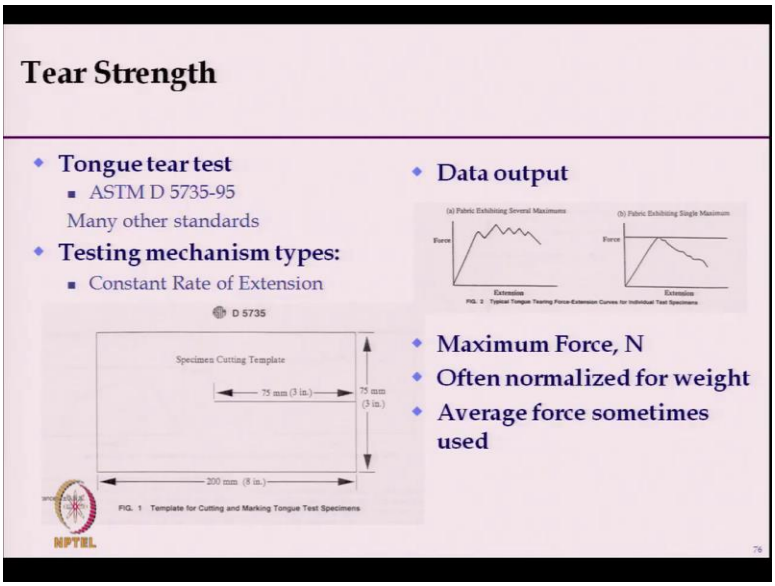

After tensile strength, the tear strength is also important which is tongue tear strength, where this is a specimen of dimension 200 millimeter by 75 millimeter as per ASTM standard. And the cut is made of 75 millimeter length, and this two sides are gripped with the jaws of a tensile tester, and tensile test is carried out. And the fabrics will tear through this zone.

And the testing mechanism is constant rate of extension. And test data output here, either we can have maximum force or average force of some of these peaks are used. And this data is often normalized for weight. So, maximum load per weight is the normalized tear strength.

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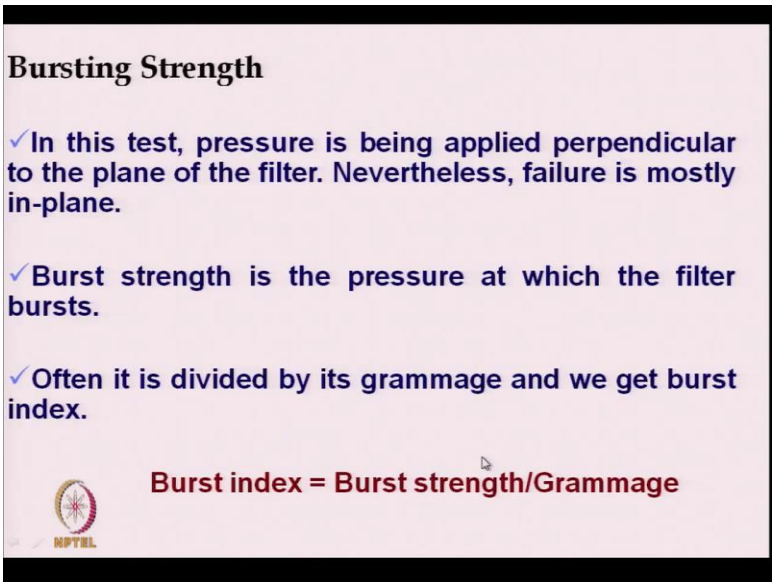

Next parameter which is very important for bursting's for the filter fabric is bursting strength. In this test, pressure is being applied perpendicular to the plane of the filter ok, but the failure is basically in-plane direction. Burst strength is the pressure at which the filter burst. Often it is divided by the grammage to get the burst index. So, the grammage is basically important where higher the grammage, higher will be the bursting strength in general. So, burst index will be is the normalized value irrespective of the grammage.

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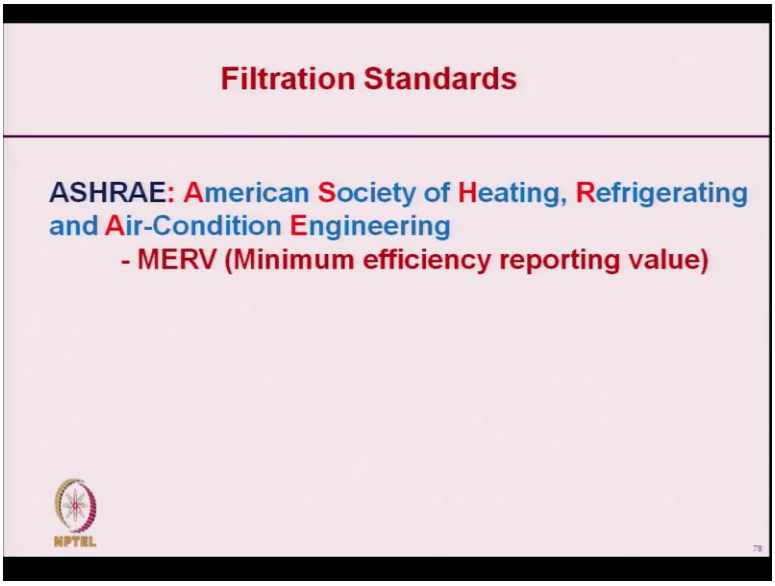

Now, coming to the standards; as I have already mentioned, there are many other standards. And two standards are widely used; one is American standard, another is European standard. American standard is ASHRAE-American Society of Heating Refrigerating and Air-conditioning Engineering. And in this standard the filtration efficiency is expressed in terms of MERV value. Now, we have to understand the MERV, concept of MERV.

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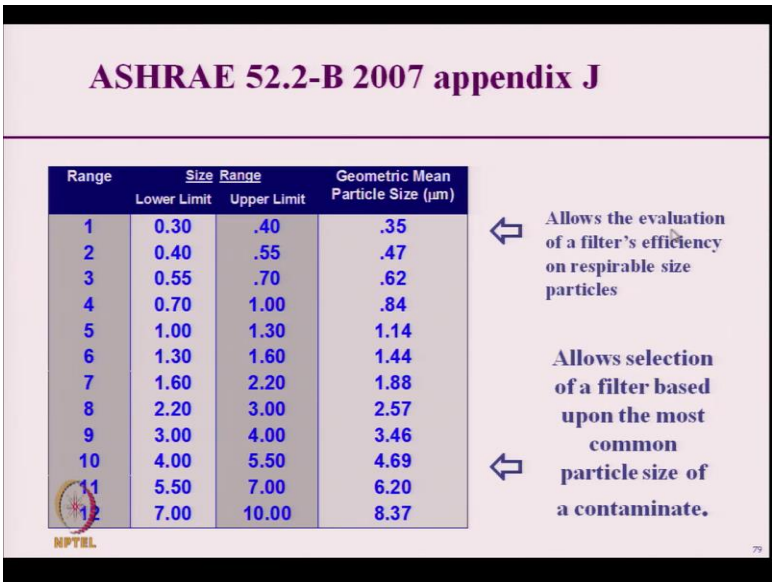

Here this is the say range of values, the range is 1 to say 12. Size range here, it is 0.3 to 0.4, these are the size. And geometric mean is 0.35 micron ok. These are the lower size, this is upper size. So, in the particles in this upper zone, it is basically used these are used for respirable size particles. All the evaluations of filters efficiency on respirable size particles. So, for testing filters and efficiency for respirable size particles are this range. And if you want to test for coarse particles, these are the particles size. Allows selection of a filter based upon the most common particles of contaminate. These are the most common contaminates.

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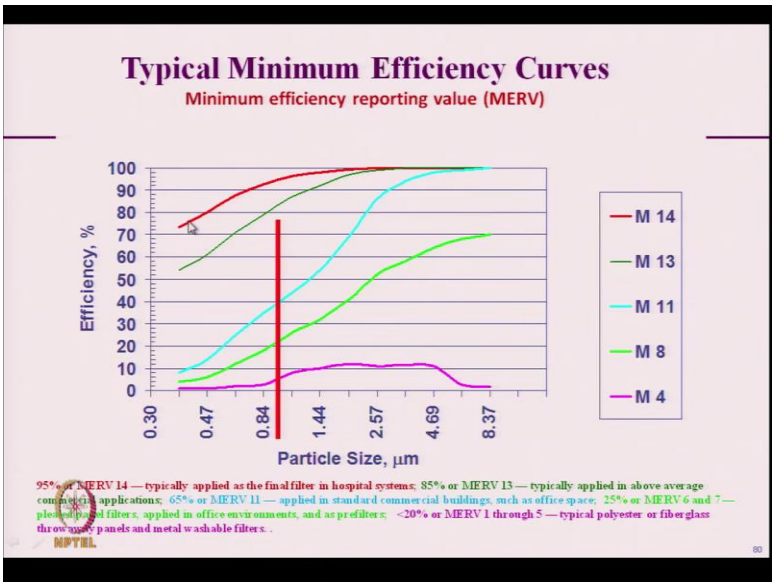

Now, let us try to see the MERV value different MERV values, and what are their areas of application. And how this efficiency changes with the particle size, now this is for MERV 14 which means, it is very fine particles. So, particle of size say 0.35 micron is very fine particle. And as we increase the particle size, the filtration efficiency will increase. This MERV 14 is the characteristics of filter media. So, if we use MERV 14 in that case, if we have a particle of size 0.35 micron, this will give a filtration efficiency of around 70 to 73 percent.

As we increase the particle size little bit say for say 1.44 micron particle size or 1.5 micron particle size around that, the filtration efficiency will be almost 100 percent. So, for this type of filter, we can have very high filtration efficiency for lower particle size. So, this is typically applied as final filter ok, this is for final filter of any filtration system.

Next is that for MERV 13, as MERV value reduces, the filters characteristics is becoming lower and lower. If we see MERV 14 for same particle size of say 0.35 micron particle size. The filtration efficiency of this MERV 13 filter has drop from 70 to 73 to 55 percent around 55 percent. But, as we increase the particle size, the filtration efficiency increases gradually. So, this is little bit coarser filters than the MERV 14, it is typically applied in above average commercial application ok. So, average commercial application above average commercial application means for very actual high required commercial

application, we can use for maybe for hospital or for different application, we can use MERV 13 ok.

Now, MERV 11, it is applied in standard commercial building like office spaces, where the filtration efficiency is lower. So, gradually if we reduce the MERV value to say MERV 6 here, which is used for different applications. So, this is MERV 1 to 5, this is MERV 1 to 5, it is for very coarse application. So, all these curves shows that the characteristics of different types of filters.

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Minimum efficiency reporting value (MERV)	Typical Contaminant	Typical Application
13 thru 16	0.30 to 1.0 micron. All bacteria, most tobacco smoke, droplet nuclei, cooking oil, copier toner, face powder, paint pigment	Hospital inpatient care, general surgery, smoking lounges, superior commercial buildings
9 thru 12	1.0 to 3.0 microns. Legionella, lead dust, milled flour, coal dust, auto emissions, nebulizer drops, welding fumes	Superior residential, better commercial buildings, hospital laboratories
5 thru 8	3.0 to 10 microns. Mold, spores, hair spray, cement dust, snuff, powdered milk	Commercial buildings, better residential, industrial workplace, paint booth inlets
1 thru 4	Larger than 10.0 microns. Pollen, Spanish moss, dust mites, sanding dust, paint spray, dust, textile fibres, carpet fibres.	Minimum filtration, residential, window air conditioners

Here the MERV values, so 13 to 16, 9 to 12, 5 to 8 or 1 to 4, this are the different ranges. And second column shows that the different types of particles this can handle. So, MERV higher MERV means, this will handle the finer particle. So, 13 to 16 MERV, it is actually it handles the particle size from 0.3 to 1 micron. 9 to 12, 1 to 3 micron. 5 to 8, it handles 3 to 10 micron. And 1 to 4, it is larger than 10 micron.

So, higher MERV filters are used for specific high end application. 13 to 16, it is applied in hospital, and different superior commercial building. 9 to 12 is its superior residential building, better commercial establishment we can use. 5 to 8 is used its normal commercial building ok, industrial workplace. 1 to 4 is used where minimum filtration is required in the residential or window air conditioner, where we need higher air flow and less filtration. So, 1 to 4 is used in all this application like window air condition ok.

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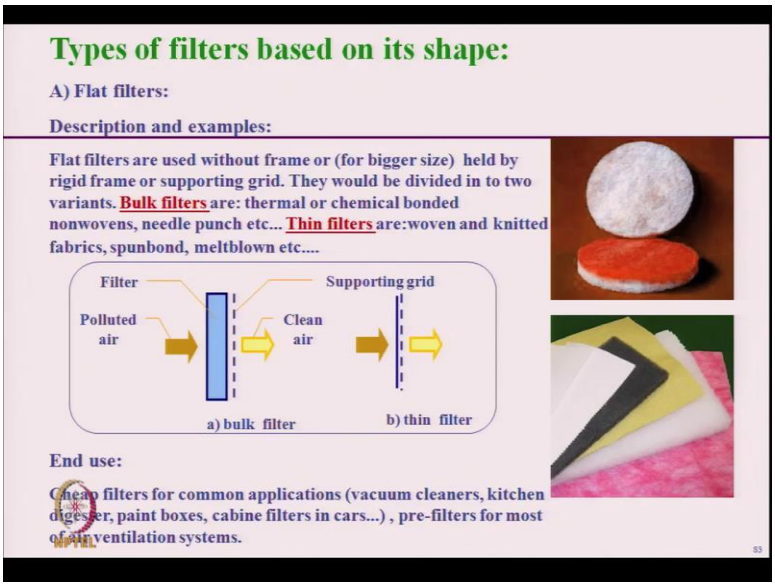

Now, we will discuss the products, there are different types of products available, filter products based on their size. First it is called flat filter, what is flat filter? The flat filters are used without any frame or with frame for bigger size, and this filters are flat in surface, these are rigid ok. They would be divided into two variants. Bulk filter, the thermal or chemical bonded non-wovens, needle punched non-woven. And another type is thin filter, these are woven or knitted fabrics spunbonded or meltblown, this is the flat filter ok. The filters are flat in surface ok.

The end uses are cheap filters for common applications like vacuum cleaner, kitchen, digester, paint box in all these applications where the filter shape is in flat condition. So, we use this type of filters or also in pre-filter sometime we use most air ventilation system, in pre filter we can use this type of filter.

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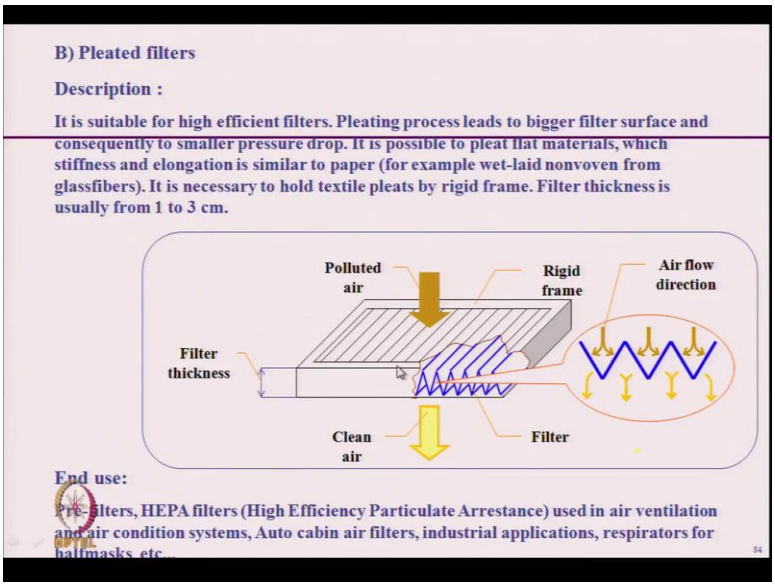

Another filter is it is called pleated filter. Pleated filters are basically it is a variation of the flat filter.

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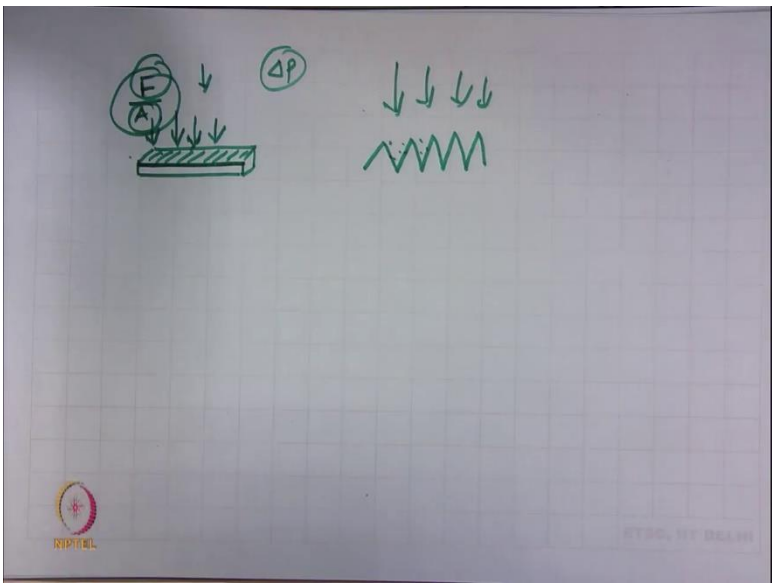

In flat filter, the shape is in flat condition, when air is flowing. Here the area of the filter surface area of the filter is limited that is why, the pressure drop will be more pressure drop is of that is force by unit area. Now, if we can somehow increase the area by having same force value, we can reduce the pressure drop, this is done by making pleats. This is

pleated filter, and the air is flowing, and the air is flowing through the larger area as it is pleated. So, the pressure drop will be reduced, and there will be more surface for filtration.

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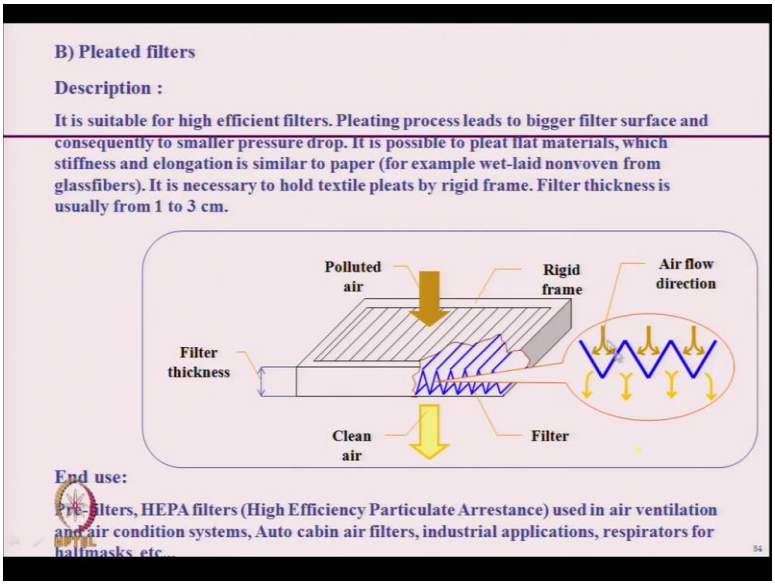

So, it is suitable for high efficiency filtration. Pleating process leads to bigger filter surface and consequently the smaller pressure drop. So, this will result lower pressure drop. And the end uses are the pre-filters, HEPA filter used for air ventilation and air conditioning system, auto cabin air filter. There are different industrial applications are also there. So, this is used and even it is used for the automobile filter.

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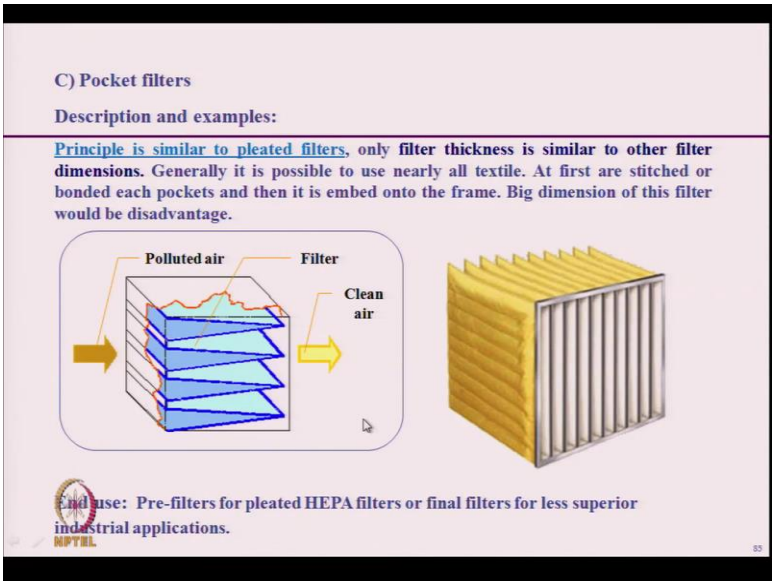

Next is that pocket filter, it is similar to that pleated filter. Only difference is that only filter thickness is similar to other filter dimension. Generally, it is possible to use nearly all textile. At first the filters are stitched, and then they are formed a pockets ok. These are pockets are formed. And the air is flowing from one direction, polluted air is flowing, and it is a clean air is coming. So, due to this pockets present in the filter structure, the area is very high area is increased. So, pressure drop is reduced. So, this is again used for pre-filter of HEPA filters.

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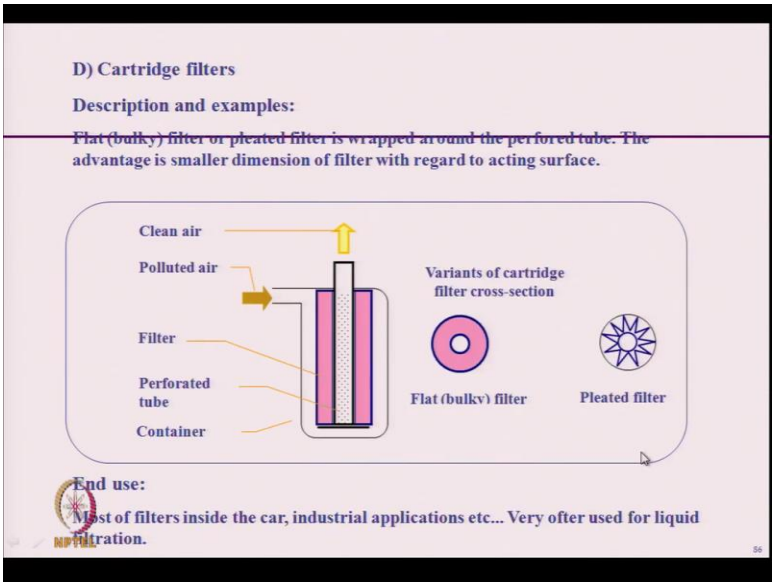

Next type of filter based on the shape is the cartridge, filter cartridge is very commonly used for many applications like liquid filter or even air filter ok. This is the filter cartridge, where the flat that is bulk filter or this is the flat filter or pleated filter is wrapped around a perforated tube. This is the perforated tube, this flat filter or pleated filter is wrapped around this, the advantage is that smaller dimension of filter with large acting surface.

So, actually this surface acting surface is very large, but dimension is very small. So, this is used, this type of filters are used, where we have smaller dimension like water filter system or car filtration that in those case the dam area the amount of the area present is very small. So, we need this type of filter. Here the polluted air or polluted liquid, it is actually flowing from this side entering into the system, and it is passed through the filter medium. And then after filtration, it is penetrating through the perforation of this tube and it is coming out, the clean air is coming out. So, this is the filtration system.

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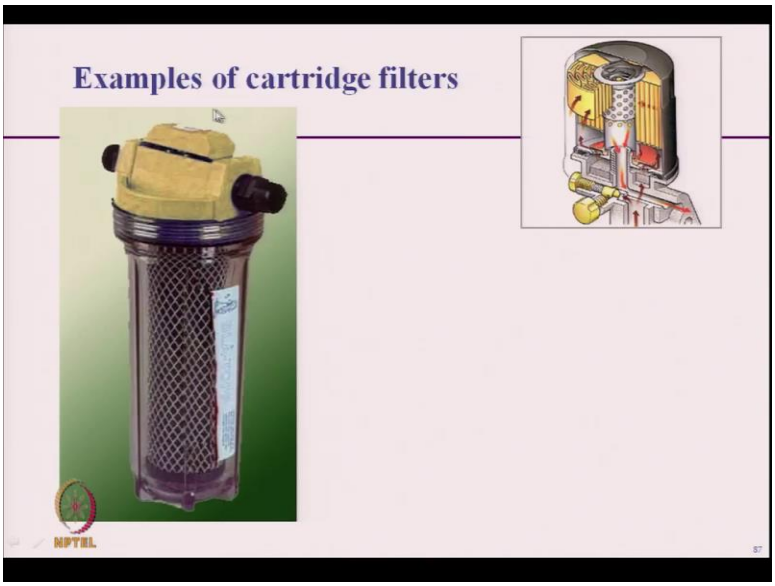

Example of cartridge filter.

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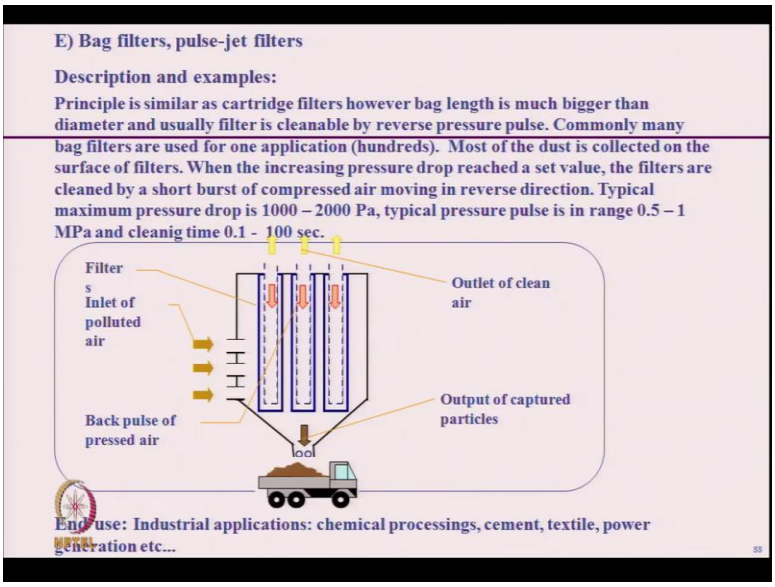

Another system is the, it is a bag filter with pulse-jet system. So, these are the very large dimension bags. The principle is similar to cartridge filter here, but here the bag length is much bigger than the diameter. So, this diameter of bag is compared to the length is smaller. So, it is a very big size bags are there. Commonly many bag filters are used for one application, 100's of bags are used to provide larger surface area. Most of the dust is collected on the surface of the filter. So, the dusty air enters from this side, and getting

filtered and it is coming out the outlet clean air is coming out from other side. And in the outer surface, the dusts are collected ok.

So, if we need to clean, we can use pulse-jet of air of pressure 1000 to 2000 Pascal; at that high pressure the pulse-jet is imposed on the filter surface for very small time of 0.1 second to 100 second that varies which cleans the filter bag, because we cannot change this filter bag repeatedly, we cannot replace also that is why, we have to use the pulse-jet system. And the dust is collected here, this is used for industries where heavy dust loadings are there like cement industry, textile industry ok, so where huge quantity of dust is generated.

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If we see the picture, this is actual dimension of bag filters, these are all bag filters are there hundreds of bags are here.

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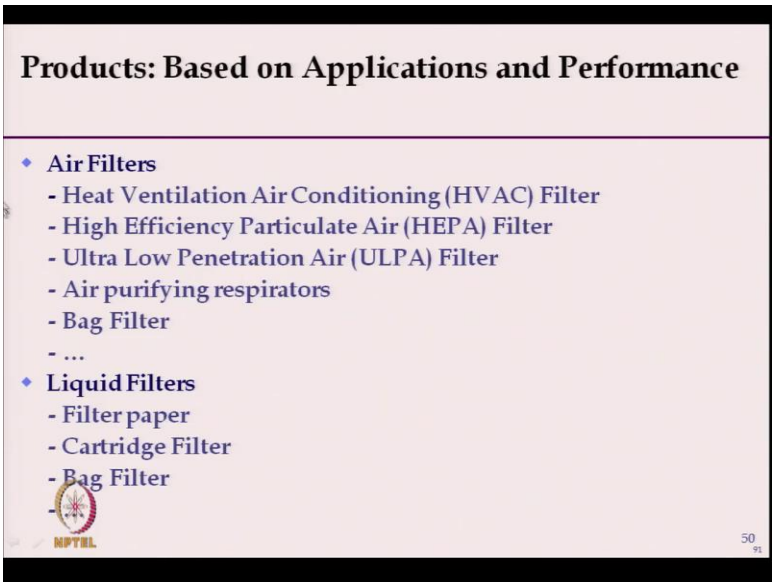

Now, we will discuss we will discuss the product based on the application and performance. So, there are air filters, and water filters. So, if we want to filter the air, so air filtrations are there. So, air filters are of different types. One is HVAC filter Heat Ventilation Air Conditioning filter. HEPA filter High Efficiency Particulate Air filter commonly known as HEPA filter. ULPA filter Ultra Low Penetration filter, air purifying respirators which is actually used for respiration purpose, face mask bag filtration. So, these are the filters based on applications or performance ok. And for liquid filter, we have filter paper, cartridge filter, bag filter also. So, there are different types of applications.

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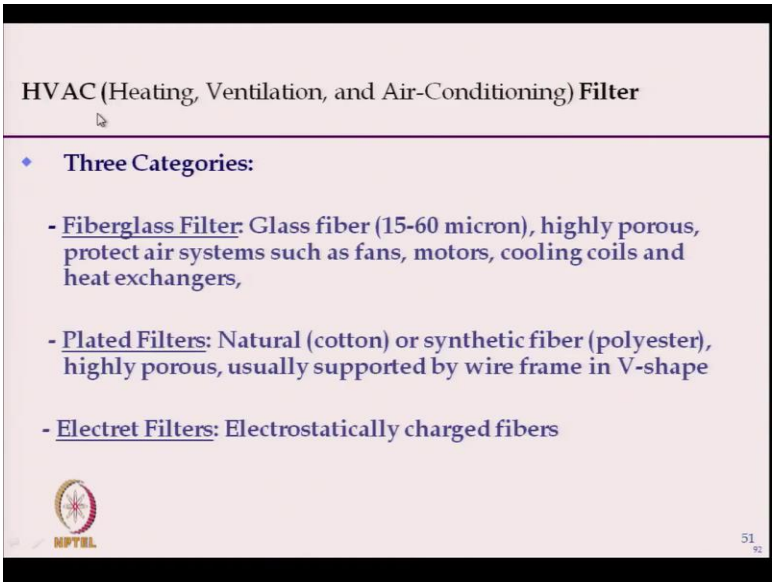

Now, if we see HVAC filter, these are of three categories. One is fiberglass filter, so glass fiber of 15 to 60 micron, highly porous, protects air system such as fans, motors, cooling coils, heat exchanger. So, fiberglass filters HEPA, HVAC filters are used. Pleated filters; natural like cotton or synthetic fibers are used highly porous, usually supported wire mesh in V-shapes this is piece pleated filter. And electric filter; electrostatic charge filter so, these are basically with low filtration efficiency.

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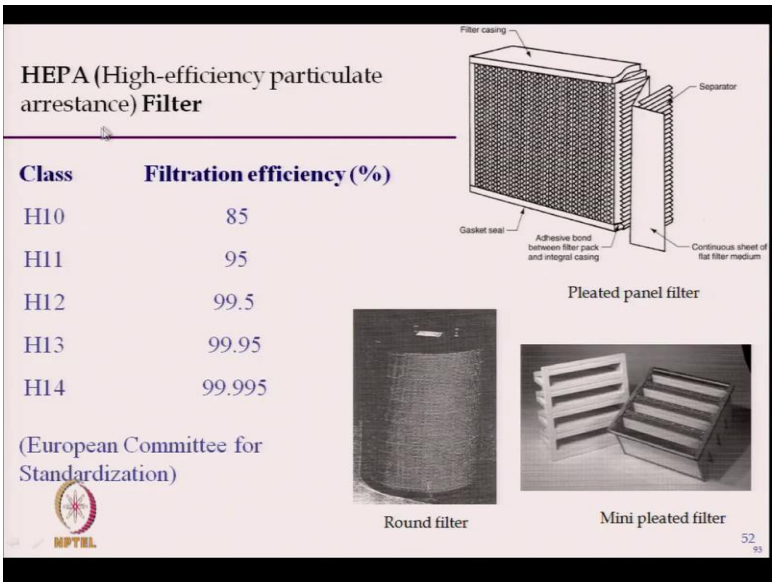

If we want higher filtration efficiency, then we have to use HEPA filter-High Efficiency Particulate Arrestance filter. This is actually recommended by European committee for standardization. And HEPA filter can be divided into five different categories H 10, H 11, 12, 13, 14. As we go from H 10, so to H 14 the filtration efficiency increases gradually with H 10 filtration efficiency is typically 85 percent. And H 14, it is 99.995 percent filtration efficiency, it is very high filtration efficiency.

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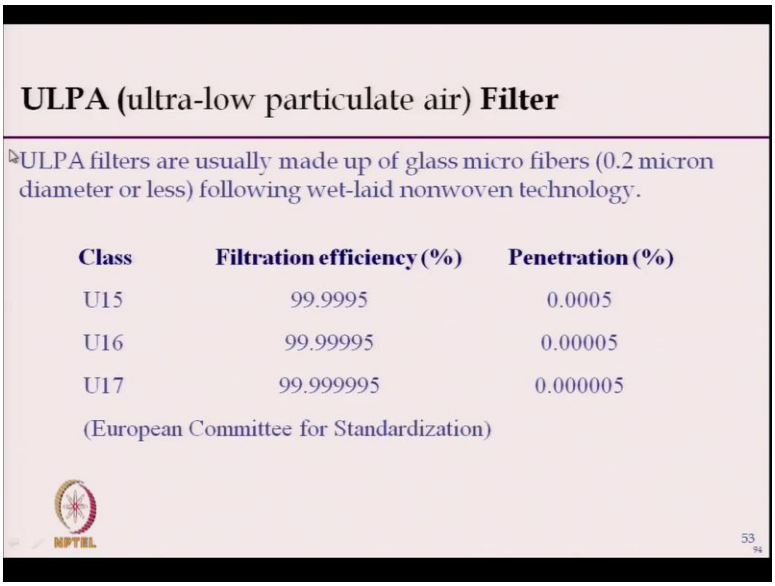

But, if we want higher filtration efficiency than this we have to go to ULPA filter, it is in the same series, but for high filtration efficiency ultra-low particulate air filter, where the filtration efficiency is very high. So, U 15, U 16, U 17, U 15 -99.9995 ok. And U 17 is almost 100 percent, the arrestance percent is very very penetration is very very low, here where arrestance is very high. So, if we need very high filtration efficiency, we must use U 17 type filter.

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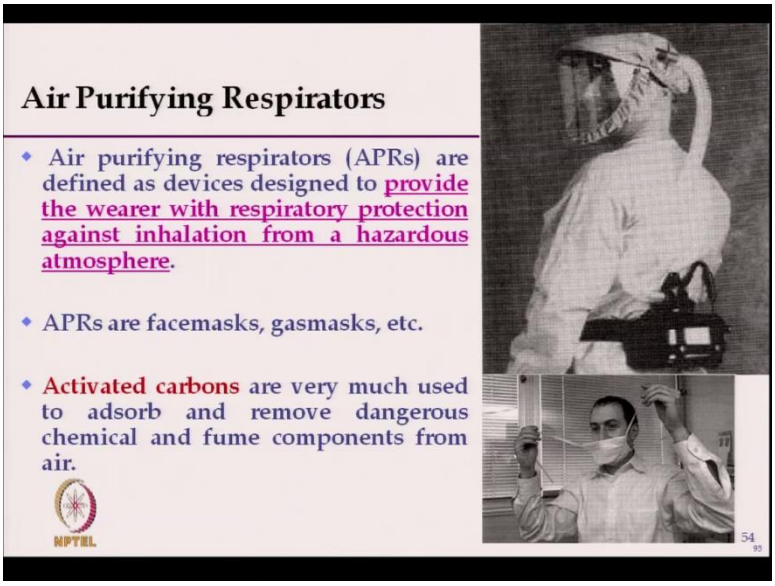

Next is that air purifying respirators, which is used as facemask ok. Air purifying respirators are defined as the devices designed to provide the wearer with respiratory protection against inhalation from hazardous atmosphere. APRs are facemasks, gasmasks, etcetera. Activated carbons are also used to absorb and remove dangerous chemicals and fumes.

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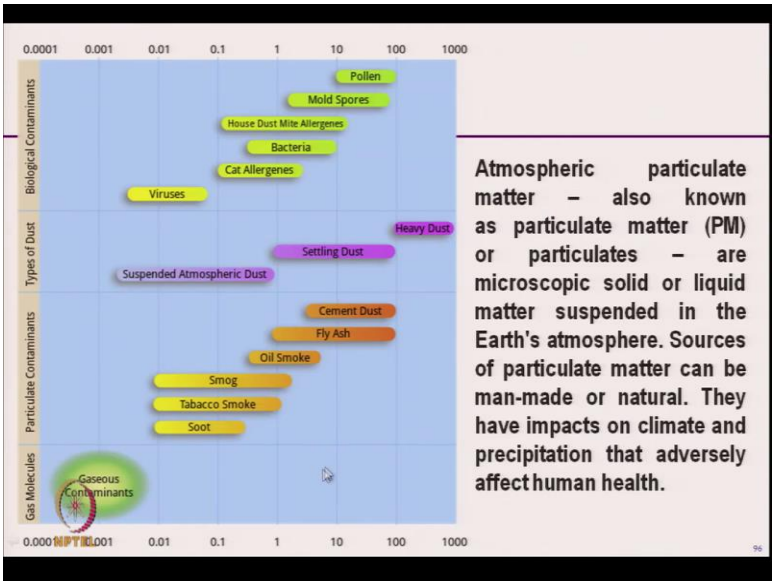

These are the different sizes of particles, their biological contaminants. Different types of dust heavy dust, settling dust, and suspended atmospheric dust. So, this suspended atmospheric dust are dangerous in nature, we have to remove this from the gas. These are having the particle size from 0.01 to 0.1 micron, then particulate contaminants these are the contaminants smog, soot, tobacco smoke ok, oil smoke. So, all this things are coming under the suspended atmospheric dust. So, we have to use that this atmospheric particulate matter, we know we should know this particulate matter to remove the this particles from the gas using the facemask.

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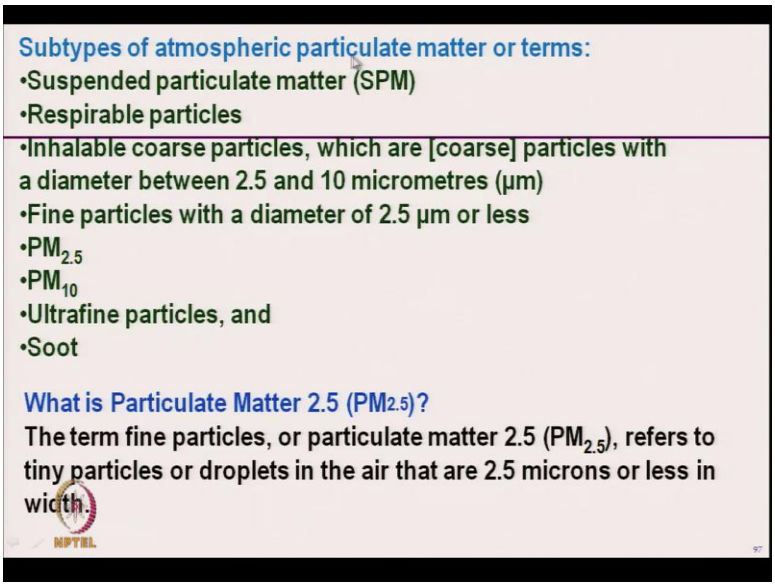

The subtypes of atmospheric particulate matters or terms are; suspended particulate matter SPM, it is commonly known as SPM. Respirable particles. Inhalable coarse particles, which are particles with diameter between 2.5 to 10 microns. And fine particles so depending on the particle size, so we can divide. So, fine particles are diameter with 2.5 micron or less. So, this diameter it is known as basically PM 2.5 or also we can expressed PM 10, ultrafine particles or soot. These are the different terms, we can use for particulate matters.

Now, most commonly used particulate matters are PM 2.5. Nowadays, we hear the term PM 2.5 very frequently? What is that, the term fine particles or particulate matter 2.5, PM 2.5 refers to tiny particles or droplets in the air that are 2.5 microns or less in width, why are you using width, because the particles are not necessary spherical in nature ok, the width is the maximum dimension.

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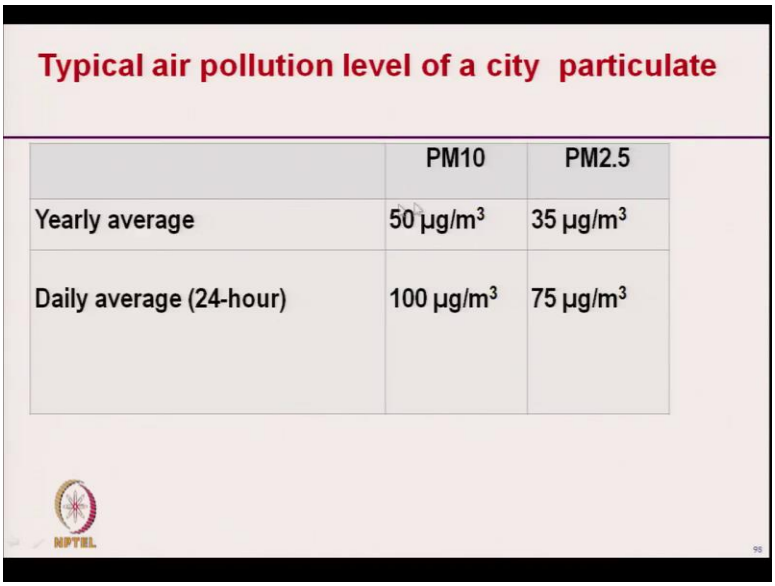

The example is that PM 2.5 is expressed in term say will say 35 microgram per cubic meter what does it mean, 35 means the particle of size 2.5 micron the if we take 1 cubic meter of air, total mass present is 35 microgram and PM 10, 10 means particulate matter of size 10 micron or less. This includes the PM 2.5 also, it is a cumulative size. And this is if it is yearly average for a particular place, and daily average for particular, so we can get this value in terms of daily average or in terms of yearly average.

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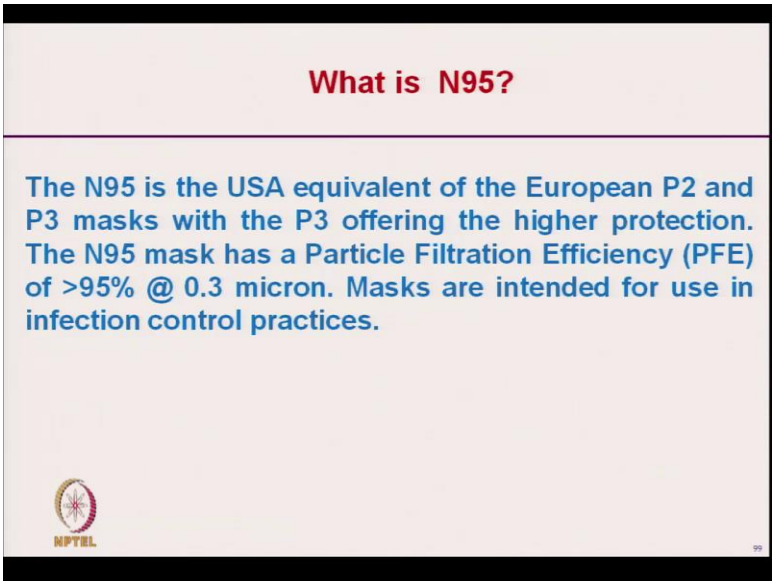

And another term which is used for mask is N95, it is very commonly used. It is the US standard which is equivalent European standard is P2 and P3 masks with the P3 offering higher protection. The N95 mask has a particle filter efficiency more than 95 percent with the particle size of 0.3 micron. So, N95 is showing that if we use 0.3 micron particles, it will have efficiency more than 95 percent. So, these masks are intended for use in infection control practices. We will stop here.

Till then thank you; thank you for patient hearing.