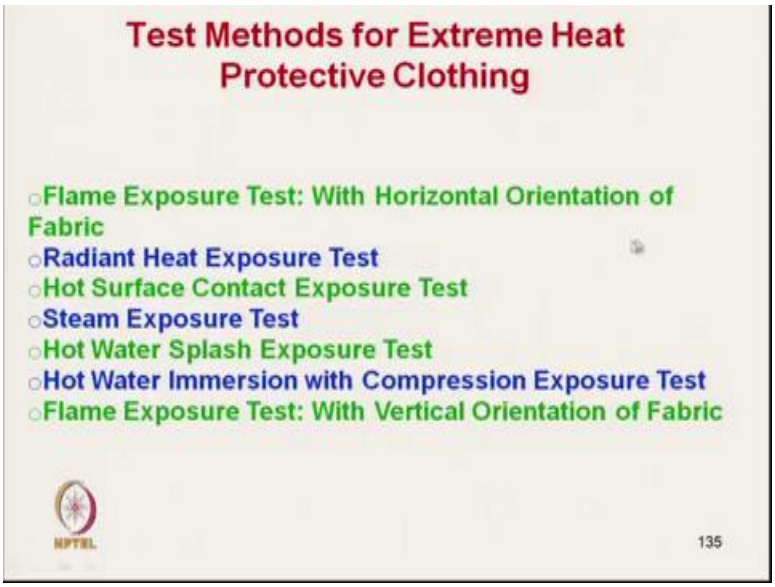
Testing of Functional & Technical Textiles
Prof. Apurba Das
Department of Textile Technology
Indian Institute of Technology, Delhi

Lecture - 09
Testing of Transmission Characteristics of Textile Fabrics (contd.)

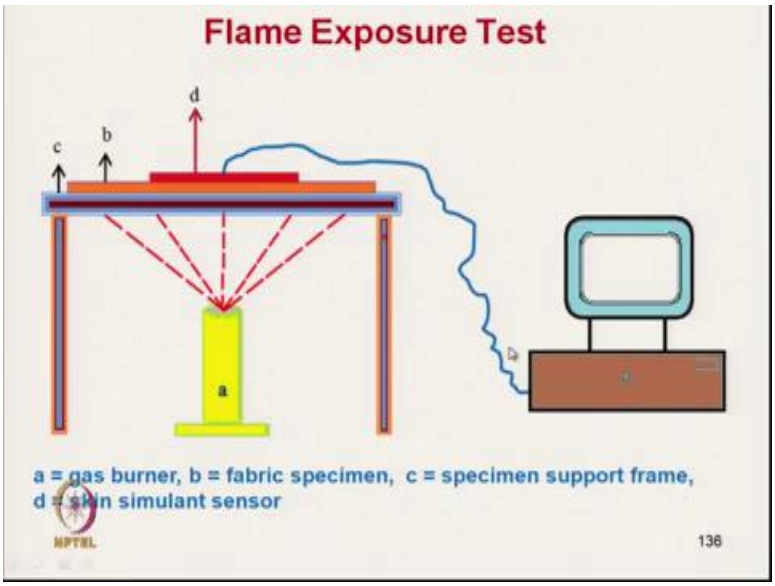
Hello everyone. So, we will continue with the discussion of Test methods for extreme heat protective clothing. As we have discussed, there are different methods for measuring the thermal transmission through protective clothing under extreme heat condition.

(Refer Slide Time: 00:47)



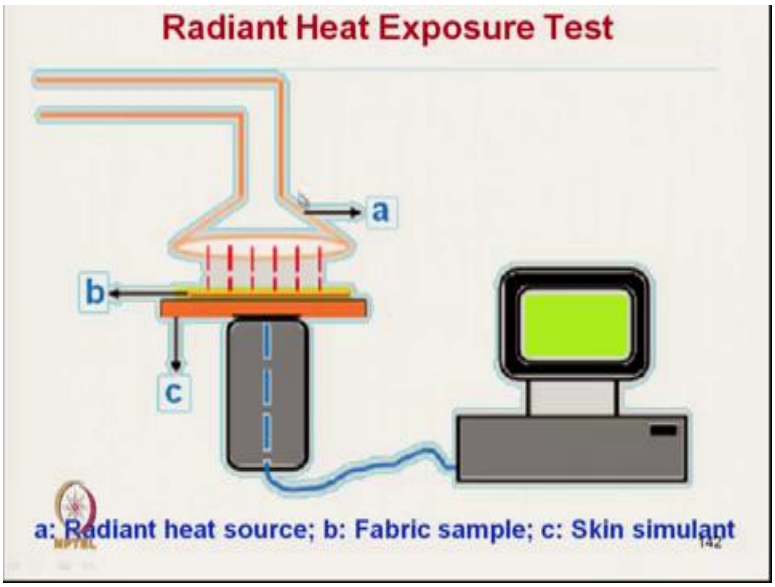
These are flame exposure test both horizontal orientation mode and vertical orientation mode, radiant heat exposure test, hot surface contact exposure test, steam exposure test, hot water splash exposure test, hot water immersion with compression test. So, in last class we have discussed two methods, that is flame exposure test with horizontal orientation and radiant heat exposure test.

(Refer Slide Time: 01:29)



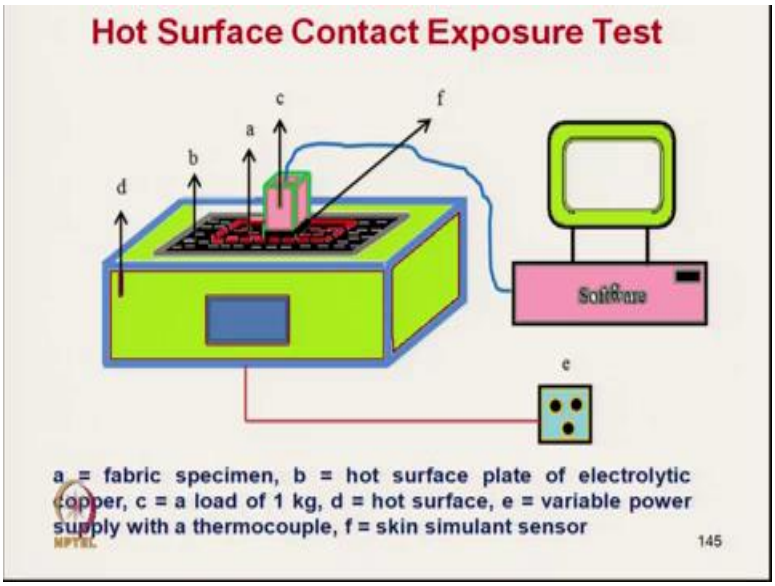
So, in flame exposure test we have discussed and also radiant heat exposure test.

(Refer Slide Time: 01:39)



Where fabric is kept horizontally and radiant heat source which actually produce heat and heat is transmitted through the fabric and on other side it is a skin simulant.

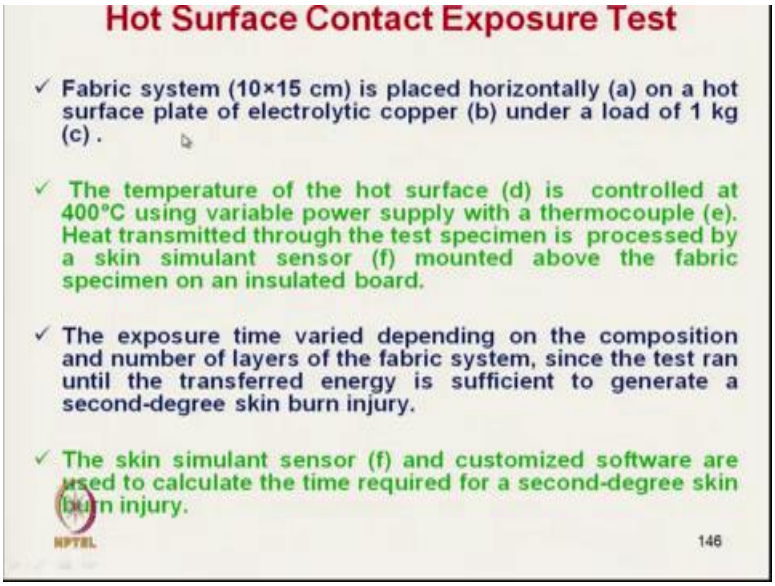
(Refer Slide Time: 02:09)



Now, we will start discussing another method which is hot surface contact exposure test. As I have mentioned, this type of situation we may actually come across this type of situation where suddenly a hot surface comes into contact with our body. In this set up, the fabric specimen a and the hot surface plate of electrolytic copper. So, this fabric a is placed on hot surface plate of electrolytic copper b and a load of 1 kg which is placed above the fabric and the hot surface is d.

So, above this hot surface, the hot surface plate is kept and above the plate the fabric is placed and just above the fabric the skin simulant which is f skin simulant sensor and then, weight is placed above that; which applies the weight a compressive weight to have better contact with the fabric and the plate and a variable power e just to supply the heat which is connected with the thermo couple ok.

(Refer Slide Time: 04:21)

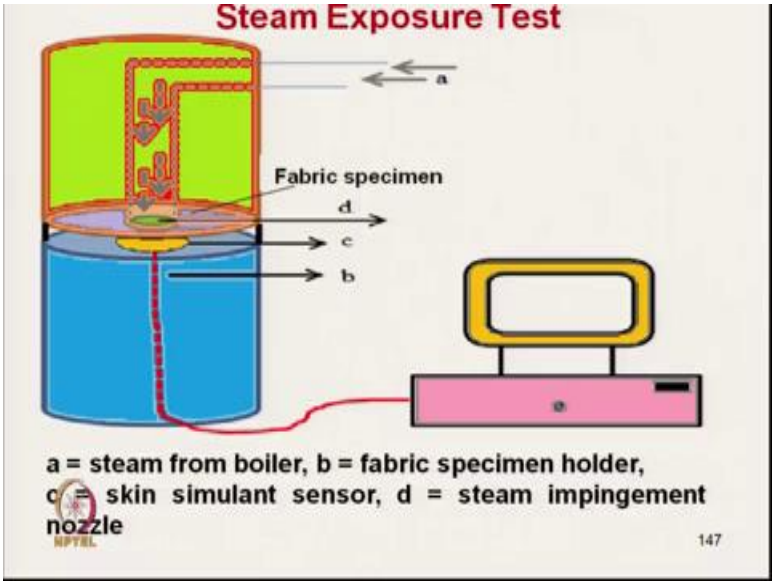


A fabric system that is fabric size which is rectangular in size 10 centimeter by 15 centimeter is placed horizontally ok, it is horizontally on a hot surface plate of electrolytic copper b under load of 1 kg. This fabric is placed, the temperature of the hot surface is controlled at 400 degree Celsius using variable power supply with thermo couple.

So, this hot surface is actually supplied with controlled power to maintain the temperature of 400 **°C**. Heat transmitted through the test specimen is processed by the skin simulant on the other side of the fabric, just above the fabric. The exposure time which is varied depending on the composition and number of layer of fabric system; that means, if the fabric layers number of layers are more we can have higher exposure time. Since, the test ran until the transferred energy is sufficient to generate a second degree burn so, our exposure time will be more because we are keeping the temperature of the hot surface constant.

So, accordingly we can calculate the exposure time, depending on the number of layer ok. The skin simulant sensor f and customized software are used to calculate the time required for second degree burn. So, the method of measurement, method of analysis and the calculation are exactly same as we have discussed earlier for others type of test.

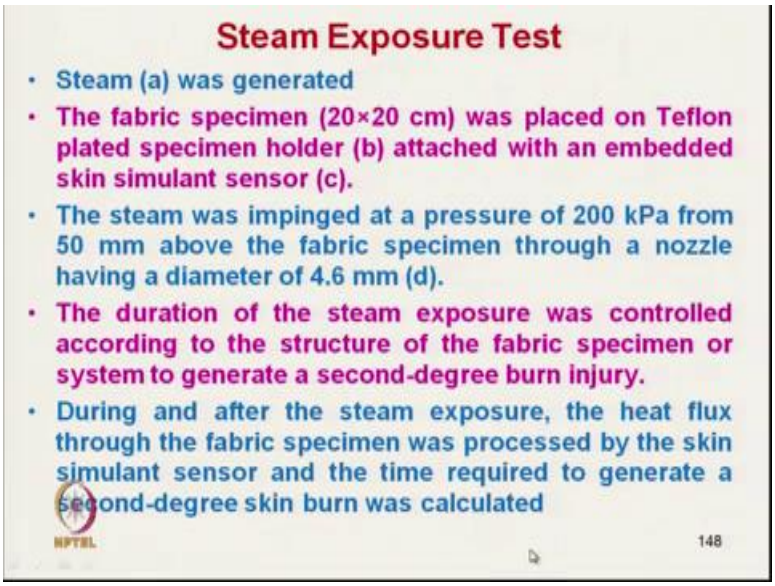
(Refer Slide Time: 07:01)



The next test is steam exposure test. Here the fabric specimen is exposed with hot steam, here a is a steam it shows the steam from boiler ok; the hot steam, b is the fabric specimen holder. So, this is the specimen holder ok, c is the skin simulant which is on the other side of the fabric and this is the fabric specimen and d is the steam impingement nozzle.

So, steam impingement nozzle which actually impinge the steam towards the fabric and the heat transmitted through the fabric due to the steam is measured using the skin simulant sensor. And the analysis and calculation is exactly same as we have discussed earlier.

(Refer Slide Time: 08:25)

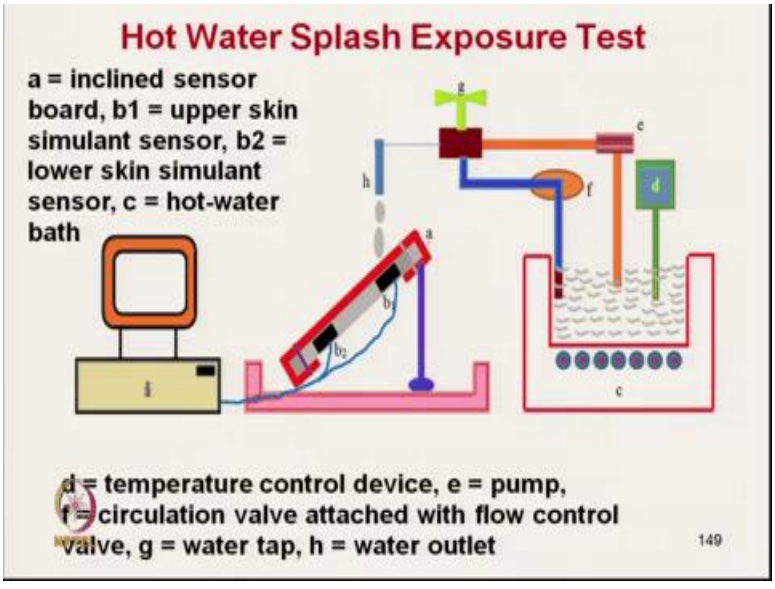


The steam a was generated from the boiler, the fabric specimen here size is 20 centimeter by 20 centimeter was placed on Teflon plated specimen holder b attached with an embedded skin simulant sensor. The steam was impinged at a pressure of 200 kPa from 50 mm above the specimen, fabric specimen through a nozzle, having diameter 4.6 mm, these are standard specimen standard size.

So, the pressure is 200 kPa and at the height of 50 millimeter; so, 5 centimeter height with the specified nozzle ok. The duration of the steam exposure was controlled according to the structure that is, number of layer or thickness of fabric, compactness of fabric; so, according to the structure of fabric specimen or system to generate the second degree burn injury. So, that is how we can actually calculate the time required.

During and after the steam exposure, the heat flux through the fabric specimen was processed by the skin simulant sensor and the time required to generate second degree burn was calculated. So, here special software is used to process the data.

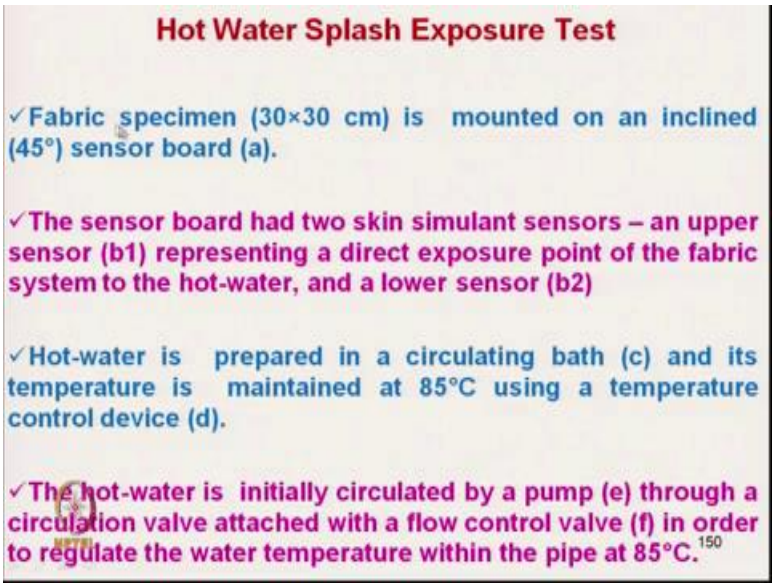
(Refer Slide Time: 10:25)



Next technique is that it is a hot water splash exposure test. This is actually important, where hot water is splashed on clothing for various application and the level of burn injury is simulated. And here a is inclined sensor board, that is the a sensor board which is inclined, this one is a and b1 is the upper skin simulant sensor. There are two simulant sensor; skin simulant, b1 and b2, b 1 is upper one and b 2 is lower one and just above the upper one the hot water splash is coming.

So, and c is hot water bath. So, this is the hot water bath, d is the temperature control device. So, this is the temperature controlled device of the bath, we can control the temperature of the water; of water as per our requirement, e is pump, f is circulation valve attached with the flow controller is a circulation valve, g is a water tap and h is water outlet. So, this is water outlet and here, this is fabric specimen which is placed on inclined sensor board.

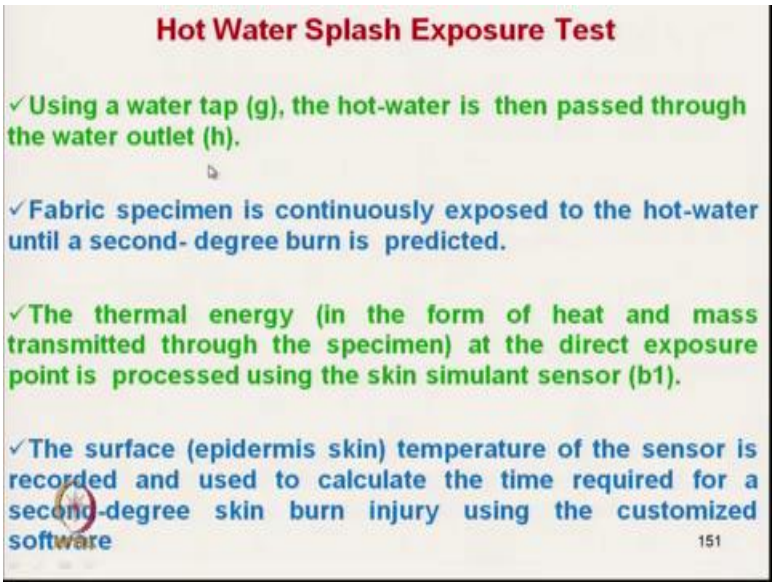
(Refer Slide Time: 12:17)



A fabric specimen, **30 × 30 cm** size is mounted on an inclined sensor board which is inclined at 45°. The sensor board at two skin simulant sensor, an upper sensor b1 representing a direct exposure point of the fabric system to the hot water and the lower sensor which is away from that ok. After wicking, the water will reach there and that will be measured.

Hot water is prepared in a circulating bath c and it's temperature is maintained at 85 **°C** using temperature control device. So, here we should remember depending on our requirement, we can change the temperature of water ok. The hot water is initially circulated by pump e through a circulation valve attached with the flow controller valve in order to regulate the water temperature within the pipe at 85 **°C**. So, by circulation we can keep the temperature of water constant.

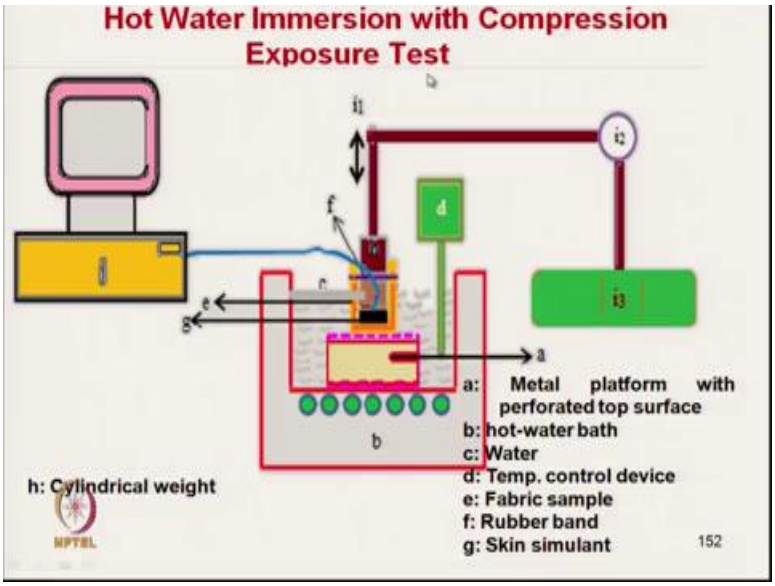
(Refer Slide Time: 14:03)



Using the water pump and the tap g, the hot water is passed through the water outlet h, the fabric is continuously exposed to the hot water until the second degree burn time is predicted ok. The thermal energy in the form of heat and mass transmission through the specimen; so, the dry heat will get transmitted as well as it's water, the water will also be transmitted through the fabric through, through wicking. So, the total thermal energy at the direct exposure point is processed using skin simulant b1.

So, that is processed and that will give us the idea of the direct exposure time, the direct exposure place and b2 which is away from b1 that also give the idea of the second degree burn away from the exposure place, direct splashing place. The surface that is epidermis of the skin, the surface temperature of the simulant sensor is recorded and used to calculate the time required for second degree burn using customized software. So, that the similar software is used here again.

(Refer Slide Time: 15:53)

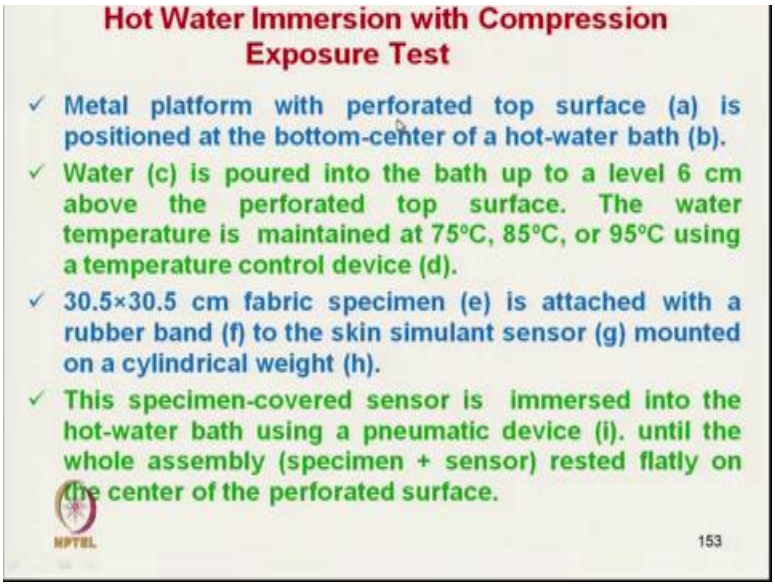


The next method is that hot water immersion with compression exposure. Sometime the fabric or a person can actually get into the hot water and this test method will predict the second degree burn time. Here, a is a metal platform with perforated top surface. So, this is the perforated top surface and this one is a metal platform and b is a hot water bath and this is water level, c is water level, d is the temperature controlled device and e is a fabric specimen, this is the fabric specimen ok.

And other side, the inside of the fabric specimen which is in black colour which is the it is g skin simulant and the fabric is actual kept tight in its position using the rubber band. And the fabric is wrapped around the actually one cylindrical weight h ok; this is the h, h is a cylindrical weight and the fabric is kept here in this place.

So, this is a system which actually allows the i1, i2 this is system which actually allows the fabric to for immersion and which it will immerse the fabric and it will take out this moves up and down.

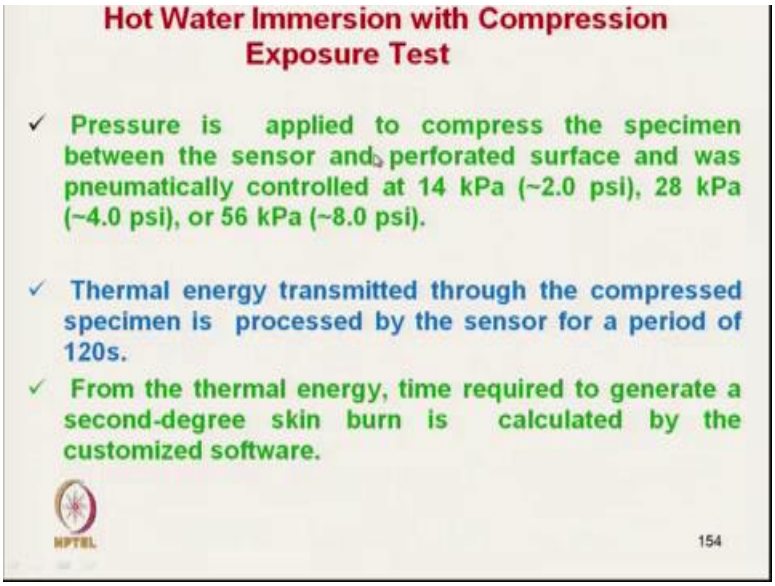
(Refer Slide Time: 17:43)



The metal platform with perforated top surface a is positioned at the bottom center of the hot water bath b. The water that is c or it is poured into the bath up to a level 6 cm above the perforated top surface. So, that is the specified height the water temperature is maintained at 75, 85 or 95 using a temperature control device, so at different temperature level the water temperature is maintained. And the fabric specimen of specified size **30.5 × 30.5 cm** is attached with the rubber band f to the skin simulant sensor g mounted on a cylindrical weight h.

So, this weight will apply certain compressive load. The specimen covered sensor is immersed into the hot water bath using pneumatic device as I have mentioned i, until the whole assembly specimen and sensor rested flatly on the centre of the perforated surface. So, that will be immersed this total system will be immersed.

(Refer Slide Time: 19:27)



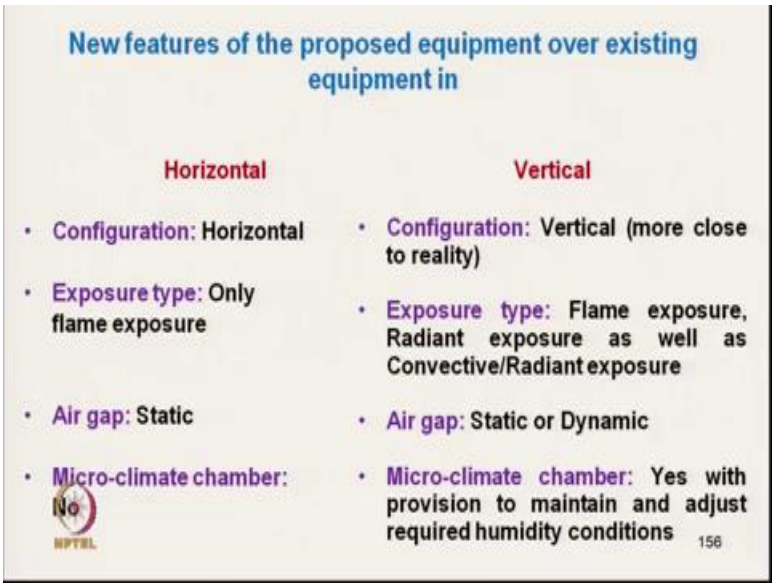
The pressure is applied to compress the specimen between the sensor and the perforated surface. So, the this load is applied the pneumatic load which is about 14 kPa, 28 kPa and 56 kPa at different level of pressure it's applied. The thermal energy transmitted through the compressed specimen is processed by the sensor for a period of 120 second that is standard for this instrument.

From the thermal energy, the time required to generate a second degree skin burn is calculated using customized software. So, here again we can predict the second degree burn.

(Refer Slide Time: 20:29)

Now, the last instrument which we will discuss, the instrument for analyzing the performance of fire protective clothing with vertical orientation of fabric, the flame exposure test with a vertical orientation of fabric.

(Refer Slide Time: 20:47)

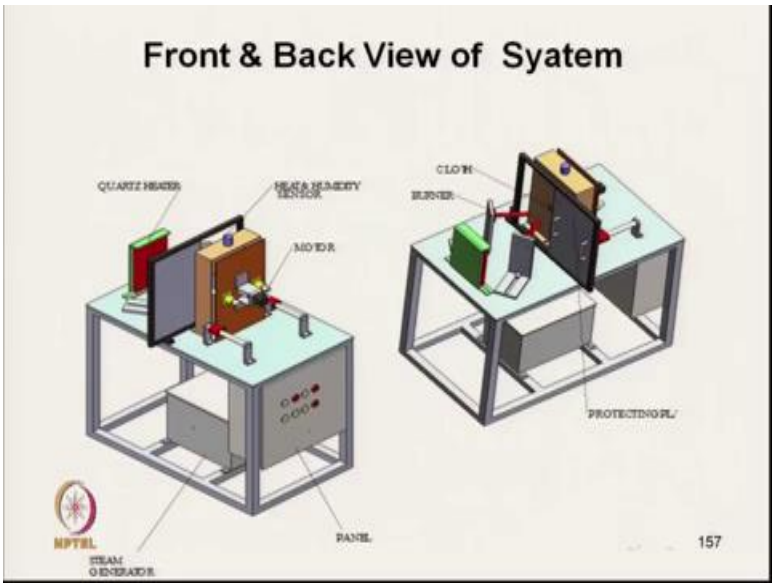


So, in horizontal condition if we compare with the horizontal condition the configuration of fabric it is horizontal and here the fabric is in vertical condition. So, when the fabric was horizontal the flame exposure was vertically upward; similarly, here the fabric is vertical which is actually more close to the reality.

In real application if we see most of the cases the fabrics are in vertical condition. Here in this instrument horizontal mode, the exposure is only of flame type explosion, only flame exposure was there, but in vertical exposure test the flame exposure as well as radiant exposure is there; so, both convective and radiative mode.

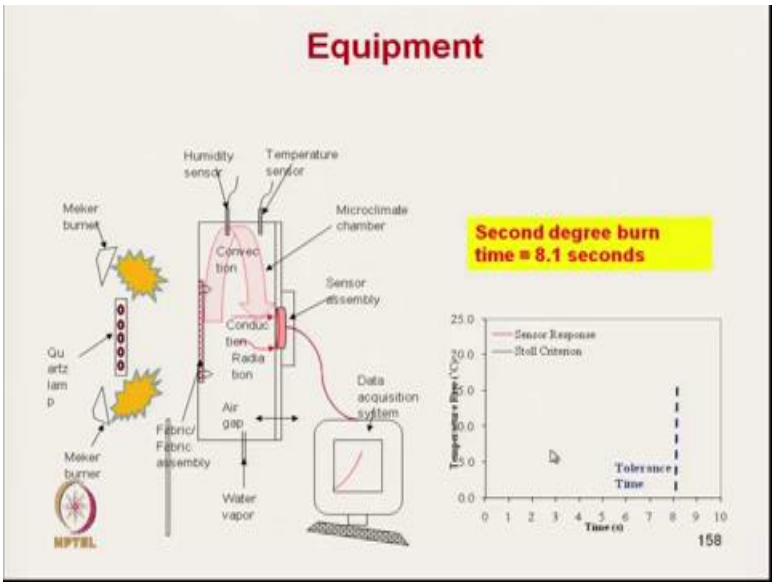
So, in this case in horizontal air gap was static there is no change in air gap, here we can keep the air gap static as well as we can change the air gap to different level ok, it is a dynamic. Microclimate chamber was absent in horizontal condition, here in vertical exposure test we can have microclimate with different adjustable humidity condition.

(Refer Slide Time: 22:43)



Now, let us see the basic structure of the instrument. Here, in this instrument quartz heater is used which will actually expose the fabric with radiant heat. And this is the heat sensor here and this is a shutter ok; where we can use this starter, we can remove the shutter when we will start the experiment and the same instrument if we add this flame. So, we can use both flame and as well as this radiant mode.

(Refer Slide Time: 23:43)



Now, let us see the equipment. This equipment has got 2 burner which will provide the flame, then quartz lamp, if you want to test in the radiant heat mode. Then this is the frame where you can place the fabric; this is the fabric specimen and through which the heat will be transmitted. And in other side of the fabric, we have the heat sensor heat actually, the skin simulant and in between the fabric and skin simulate in earlier all the experiments what we have seen, the skin simulant was just behind the fabric specimen.

Here we have created one chamber which will simulate the micro climate and the distance between the fabric and the skin that is skin simulant can be changed which will simulate the micro climate thickness. This is the fabric specimen and here air gap is maintained variable air gap and this is the sensor skin simulant and which is connected with the computer. The data the heat received by the this sensor it is recorded; the temperature is recorded and this is the microclimate chamber where we can change the humidity.

So, by water vapor; we can inject water vapor to change the humidity which will simulate the sweat moister vapor in our micro climate between skin and the fabric and this is humidity sensor and thermometer to measure the temperature. And this distance is variable, we can change the distance and here it is a shutter. Shutter is used just to protect the fabric before and after test, during test this shutter will be actually removed.

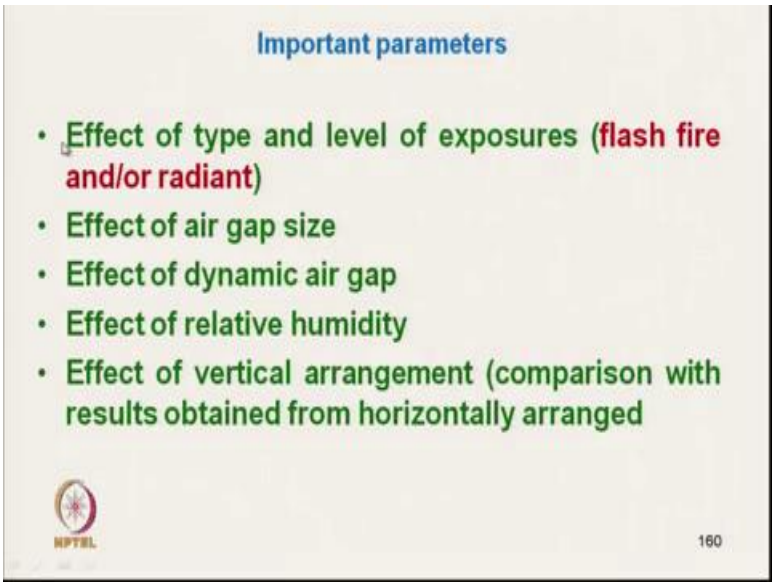
So, this flame burner is actually we have started and then this shutter is removed; once the shutter is removed, that the fabric will receive the heat from the flame or from the radiant source and the heat will get transmitted through the fabric and this heat will be measured by this sensor. And we will get the data temperature verses time data we can get and this humidity to maintain the humidity in uniform here this can be circulated. So, this is getting heated and the computer is getting signal and it is recorded.

(Refer Slide Time: 27:51)

So, we will get the this curve we can measure the second degree one time ok, as per this curve we have got the second degree burn time of 8.1 second so, but the unique feature of the instrument is that it is a vertical configuration more close to reality as compared to existing instrument. Wide range of test can be covered that is test standard can be covered the radiant exposure test as per ISO 6942 can be covered ASTM F1939 ASTM F2702, also we can have flame exposure test as per ISO 9151, ASTM 4108. Both flame and heat radiant heat exposure we can test as per ISO 17492, ASTM F2700 and ASTM F2703. So, wide range of standard can be covered using this equipment.

And dynamic air gap between fabric and skin which simulates the movement condition of a person; the micro climate control the provision to control relative humidity in the air gap for sweating condition.

(Refer Slide Time: 29:39)

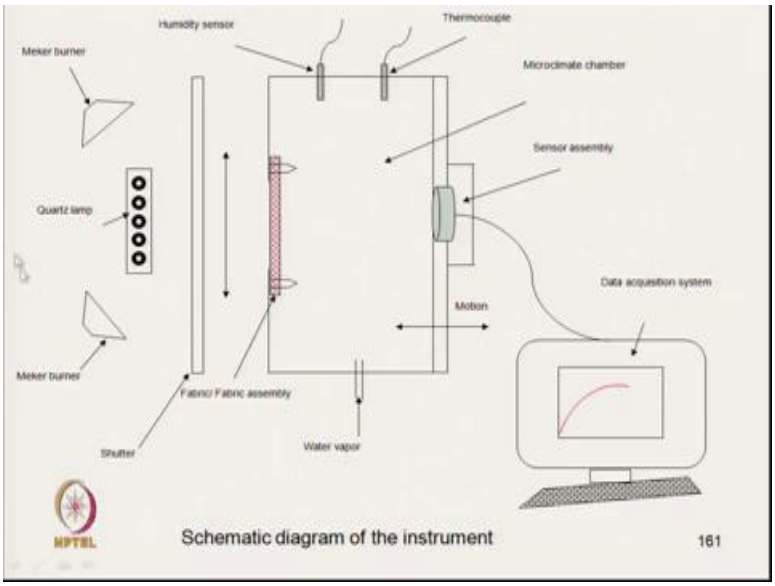


So, for different sweat condition we can simulate the amount of heat transmitted through the fabric and the parameters we can test in this instrument. The effect of type and level of exposure so, may be flash fire or radiant, effect of air gap size, effect of dynamic air gap, effect of radiative humidity so, relative humidity we can measure the effect of relative humidity; so, effect of vertical arrangement so, comparison with result obtained from horizontal arrangement.

So, all this experiment one can do, we can get white range of information; wide range of information related to flame exposure related to radiant heat exposure. So, we have reached the end of this part where we have discussed the test methods for the functional textiles, that is the low stress mechanical characteristics for prediction of handle and the transmission characteristics.

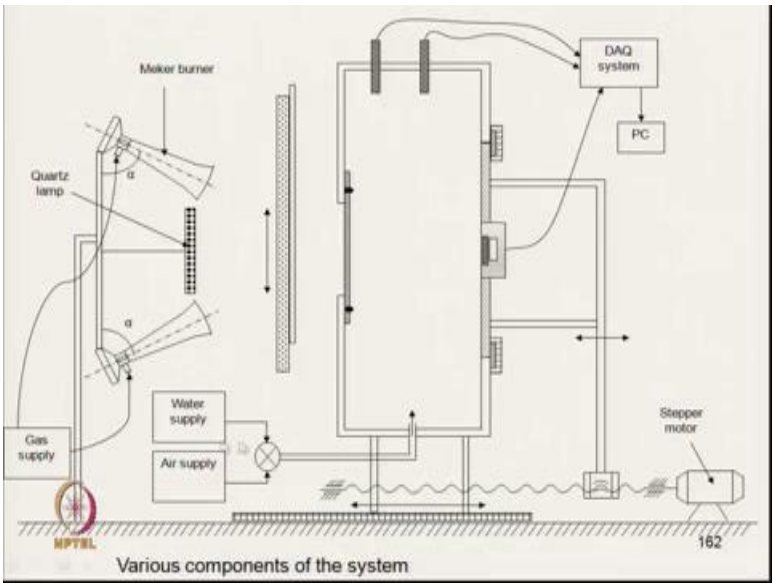
So, we will end here we will stop at this point, in next class we will start other segment that is the testing of the technical textiles.

(Refer Slide Time: 31:21)



So, this is the picture which we have discussed earlier also.

(Refer Slide Time: 31:27)



The other space diagram, that is schematic diagram of this instrument. So, till then thank you.