**Micro Irrigation Engineering**
**Prof. Kamlesh Narayan Tiwari**
**Department of Agriculture and Food Engineering**
**Indian Institute of Science, Kharagpur**

**Lecture - 47**
**Standards and Quality Assurance of Sprinkler Irrigation System Components**

Hello participants, I welcome you to micro irrigation engineering course on this particular topic, lecture 47 of standard and quality assurance of sprinkler irrigation system components. In lecture 46, we discussed about standards and quality assurance of micro irrigation system components. Now these standards are very important to get the good quality material which can perform well in the field and mainly agricultural equipment, these equipment's are kept in the field for longer period. It passes through the atmospheric conditions, ambient condition, and harsh weather. So, such material should not get deteriorated by the hot sun or solar radiation or it should remain there as per the expected life which manufacturers claim. So, it needs to be get tested.

So, here we are discussing about the polyethylene pipe, which are used for conveying water, in the network of irrigation system of sprinkler irrigation system. There are joints, and these are the quick coupling joints and fittings which are used for the joining the pipelines or making fittings. Then design an operational requirement for operating the sprinkler irrigation system so these are also important components while we are installing the systems. And test methods for uniform distribution of water through sprinkler nozzle this has been also covered in this particular lecture.

The BIS, which is Bureau of Indian Standards for sprinkler irrigation system components. So, these are the specification which has been meant for polyethylene pipes which is, IS 1415-1 (1999) which is for irrigation equipment is sprinkler pipes part 1. Then for quick coupled polyethylene pipes because these pipes are of sub-standard length of 3 meter 6 meter 9 meter or 12 meter long and so it needs to be fitted quickly it should not take time. So, and whether they are leak proof, so this is the standard which has been given by BIS which is 1415-1 (2008) for irrigation equipment sprinkler pipe part 2 and then for design and operation requirement this is the standard which is, IS 1223-1 approved in 1996. So, this is for rotating

head sprinkler nozzles and test methods for testing the uniformity of water distribution. This is also it is given at 12223-2. So, one need somebody wants to go in deeper about this part more detail then these standards BIS standard one should check these are available in the library.

So, tests for polythene pipe as I given you this is IS 1415-1 (1999). So, test which are required to carry out one is the Carbon Black Test, which in the short form we called CBC test, and then the Carbon Black Dispersion test, Ovality test whether pipe remain in the same, it has not deformed when it is subjected to load on a particular temperature when it has been given so ovality test is carried out. Other test is to find out whether the units it has got uniform wall thickness, so, there is a test for this. And then hydraulic characteristic curve reversion test, this is another test which is done. Tensile strength test, for elongation and then density test, melt flow rate test so these are the 9 test which has been suggested for the sprinkler irrigation pipes.

So, when it comes to the Black Carbon Test, Black Carbon Test offers excellent mechanical properties and resistance to oxidation, weathering and it is used to assess the level of carbon content which is important to keep the control of plastic properties. So, permissible limit that how much there should be carbon content. So, this carbon black content in the permissible limit is given as a 2.5 + - 0.5%. Now as per the suggested, this is the standard test procedure which has been set in the IS 2530 (1963) one should use this test to know the how much is the carbon black content available.

This is the device which is used to find out the carbon black content and then it is a calculated by using the CBC is given by

$CBC = (w_1 - w_2) \times 100 / w_3$

Where w1 is the weight of residue in gram. So, residue plus boat and then w2 is the weight of boat in gram and then w3 is the weight of the material in gram. So, this way one can find out how much is the black carbon content in this plastic pipe. So, this is the black carbon dispersion test is used, within the plastic to get required stability and large agglomerates rates of carbon black can cause the opposite of the desired result especially in pipe material.

So, using that particular test procedure, which has been specified in the manual that can be used and then this particular thing which you are seeing in the right side of the diagram this shows that the portion of the black carbon dispersion it is within the field of view of one millimetre under 200 times magnification. It has been then, so whatever the fleek, white streaks which are seen there, that is giving us to find out the number and size of the agglomerates which means that is in the standard way. So, the means this particular CBD is the material under test shall be considered satisfactory if the specimen show a uniform background free from white streaks and the number and size of the agglomerates are not greater than number and size of agglomerates given in this particular figure. So, this is a standard from there actually it is compared.

Ovality test as the name is said that quality means, it has deformed from the original shape. So, ovality is a measurement to express percentage of the variation between the maximum outside diameter that is OD minus minimum OD divided by the nominal OD that is outside diameter. So, ovality is estimated in percentage that is maximum outside diameter minus minimum outside diameter divided by the rated outside diameter. That is the manufacturer give that what is the rated diameter it is available that is design diameter. And if there is any deformation in this takes place that deformation should be within the prescribed limit.

So, this is the device and then the procedure is stated in this IS code. So, the IS code as well as ISO code of 3162. So, far the nominal diameter of 63 millimetre in size as well as outside diameter. So, nominal tolerance is allowed that is a + - 0.6 millimetre. And ovality is given as 1.5 this is the ratio you have seen that the how the maximum diameter minus minimum outside diameter divided by the rated diameter, so ovality it is estimated here. So, this should be within 1.5 and then another one is set for 75 millimetre diameter; this is the range which is given. So, this particular device is used to find out the roundness to the oval, oval means ovality of the pipe size.

The Reversion Test, it find out the presence of moisture and volatility of the material. So, here the test procedure to find out how much is the moisture present and then what is the volatility of the material. It is given in this particular IS code 4985 and these are the two codes which has been stated and then here the specimen is placed at 150 degree Celsius on a

tray with the smooth surface and this smooth surface is provided with a talcum powder and then it is found that how much time it should take, the time taken in case the pipe of wall thickness not greater than 8.6 millimetre. Then 60 minute time is given and in case the thick wall, the wall thickness is greater than 8.6, then 120 minute time is given and for greater than 14.1 millimetre 240. So, these are the values which are prescribed for a different thickness. Wall thickness of the material to find out the how much moisture and the smoothness is available in the pipeline.

Wall thickness, this is the schedule numbers for the pipe size or wall thickness is estimated to get uniform relationship between the design pressure and allowable stress. So, wall thickness is given by 1000 multiplied by the ratio of the pressure that is the design pressure divided by the allowable stress. So, this ratio multiplied by thousand gives the wall thickness. And this is all further means the thickness is basically, you can see here this is the in the diagram right side diagram this is the thickness of the pipeline. So, thickness is also prescribed for the different diameter of the pipeline and also for rated pressure, how much pressure, it is it should withstand. So, according to the pressure and the stress is developed the thickness is given. So, this is for class 2 pipeline which is of nominal diameter of 63 millimetre the wall thickness it is in the range of minimum 2 to 2.4 that is a maximum value and in case of class 1 pipe which is of 75 millimetre diameter this is also 2 to 2.4 thickness is recommended.

Internal pressure creep rupture test, means, this is for evaluating the effect of long-term stress on pipe material in order to prevent failure. So, test pressure is given by

$$p = \frac{2\ \sigma_i\ s}{(d - s)}$$

Where

$p$ = test pressure (Mpa)

$s$ = minimum wall thickness (mm)

$\sigma_i$ = induced stress (Mpa)

$d$ = nominal outside diameter (mm)

So, this is nothing but the internal diameter of the pipeline. So, it is estimated that your test pressure that is your internal pressure creep rupture test. It is estimated that is a test pressure p is given here, when it has been quality test it is done. The test temperature is 80, for 80 degree Celsius the duration is of 165 hours and then induced stresses it should withstand 3.5. And then the type test this would withstand the induced pressure of 3.8. So, sample should remain intact while passing through the given temperature and pressure. So, for to carry out this particular test, this is the code which has been specified and that is given for this particular test.

Tensile test, the tensile test it is an ability of plastic material to withstand maximum amount of tensile stress while the pipe is or material is pulled or stretched without failure. So, it is given by maximum tensile load sustained by the test specimen divided by the original cross-sectional area of the specimen at breaking point. So, tensile strength at yield minimum it is given 19 mega Pascal and elongation at break minimum it should be 500% and the instrument which is used it is UTM that is universal test machine. Test procedure code is specified and that is a 2530 and according to ISO this code is the 6259. So, now these procedures can be obtained from these codes. And then how in this machine, the sample is kept. So, this is a test piece and the dimensions of the test piece, and when we are doing it, this is specified in this particular table and then how the sample is equipped in the machine and then the test means for HDPE pipeline this particular. So, there is a research paper by Alfitouri et at. (2018) they have published research paper and this paper is published in the international journal of applied engineering research. So, for detail to carry out this particular test. One can refer this particular paper.

Then density of pipe material is another test which is carried out. So, density of a pipe sample may change due to change in the crystallinity, loss of plasticizers, absorption of solvent, etc. So, it is important to know that density varied with the temperature mainly because these pipes are kept in the field it undergoes several types of the temperature it may go in a very cold region means the extreme cold region. So, very low temperature and during hot summer temperature where the temperature goes more than 50 degrees centigrade in our country itself such conditions exist should this density test is important from that point of view. Normally, density shall vary between the 940.4 kg per cubic meter to 958.4 kg per cubic meter. It should

not differ from nominal value by more than 3 kg per cubic meter. This is the standard means this is the standard prescribed by BIS. And this is the code of BIS code which has been given that 2530 should be referred for making the density test. A density test which is the means your density of the polyethylene pipeline is estimated by using this expression which where it is given.

$\rho_p = (a_1 x\ \rho_{ba}) \times 100 / (a_1 - a_2)$

$\rho_{(corrected)} = \rho_b - 4.5 \times c$

Where,

$\rho_p$= density of the polyethylene ($kg/m^3$)

$a_1$= mass of the specimen in air (g)

$a_2$= mass of the specimen in butyl acetate (g )

$\rho_{ba}$ = density of butyl acetate ($kg/m^3$)

c = numerical value of the percentage of carbon black in the material

So, this way one can find out the density of the pipe material.

Another test is melt flow rate. So, this test is used to determine the exact time extrusion response time or behaviour and the temperature at which the polymer material will melt. And this test procedure is specified in this particular code that is, IS 2530 (1963). The melt flow rate should vary in the means it is in the range of 0.2 to 1.1 gram means, this is the limit it has been given for 10 minutes and fall within + - 30% of the value declared by the manufacturer. So, this is the thing of the test one should follow for this test. And this is the device which is used that is a melt flow indexer where this sample is kept it. So, melt flow index it is the measure of how many grams of polymer flow through the die in 10 minutes. So, this is the device which is used and this is computed by using the expression that is the average weight of cut off sample multiplied by 600 divided by t that is the time interval in second so this give the MFR value.

So, we discussed about the in case of your plastic pipes those test means this your density, melt flow rate, carbon black, carbon black dispersant. We discussed about wall thickness we discussed about the tensile strength. So, all those tests we did it in case of pipe, so those tests are also applicable for the quick coupled polyethylene pipes and fittings. And this is the

specification for this, then other tests which are there in addition to these 5 tests. There are other tests which are applicable in case of quick coupled polythene pipes these tests are holding attachment of coupler parts, leakage test, rubber ring.

So, holding attachment for the coupler it should be strong enough to withstand the pressure, two times the working pressure of the pipe. This is the important thing means when any pipe it is joined, so, it should be this much time, and this much of pressure it should be 2 times of the working pressure. Leakage is another very important component. If this leakage when water comes in pressure so, there the pipes should not leak from the joints. So, this is important. So this should be in a prescribed limit and during the test pressure shall gradually increase from 0 value to the maximum pressure and this pressure is given for one hour duration and then leakage test is conducted.

The rubber ring, this is the ring which is provided to prevent leakage from the pipeline wherever we are joining the quick coupling devices. So, one pipeline means with the male and female these 2 pipelines. So, there is O ring and this O ring is made up of a rubber high quality rubble material. So, this is maybe this is made up of a nitrile or neoprene such type of material used and this should have, it should pass through a specific test and this test is carried out and then one means it is a form that means the black colour performance and then portable shore hardness such things are being carried out at by giving the temperature of 70 degree centigrade and this is kept for 7 days and then the deformation is taken that it should be within the 10% of the value.

Then design and operational requirement of the irrigation equipment. Rotating sprinkler part one is specified by this particular code. And then the test for finding out the uniformity of water distribution it is expressed by this particular code and given here. So, let us try to know what are the tests which are performed? So, test for rotating sprinkler, so it is a test for resistance of the nozzle, test for resistance of hydrostatic pressure at ambient temperature, then hydrostatic pressure for high temperature, uniformity of rotational speed, then test of distribution, test of range of effectiveness effective pressure these are the tests which are used for rotating head sprinkler.

So, this is the device which you are seeing the top portion is the rotating head sprinkler and it is mounted on the riser pipeline. And then all the test which you see here that is carried out and then what should be the height what should be the nozzle height from this connection. And then there is a pressure gauge which is mounted here to find out at what is the operating pressure the pressure this particular sprinkler nozzle, it is operating.

So, these nozzles the sprinkler head these are mounted it could be of metal sprinklers or it can be plastic sprinklers. So, metal sprinkler threaded conduction shall withstand the torque of 50 newton meter for threads up to 25 millimetre means for one inch then we can say up to 1 inch thread the torque should be this range and for plastic sprinkler a torque of 100 newton meter for threads greater than 25 millimetres without showing any sign of damage during the test. So, this is the test for the resistance.

Test to hydrostatic pressure at ambient temperature. So, it is conducted to test the recommendation given by or prescribed by the manufacturer and then this is carried out. So, it is starting from the one fourth of the test pressure in the stages and it goes 200 kilo Pascal and holding the system pressure for five second at each pressure gauge for metal sprinkler. This is for the plastics, when metal sprinklers when it is done that this maximum pressure is twice the maximum effective pressure for 10 minutes, for plastic sprinkler, this is a twice the P max per one hour at ambient temperature and no defects and leakage appear during the test. Test for resistance to hydrostatic pressure at high temperature so this means that was for the ambient temperature, normal temperature at place but ambient means high temperature means particularly during places arid region particularly in Rajasthan conditions the temperature goes very high. So, our sprinkler should withstand it should work there so for that particular pressure this should be tested. So, test assembly is to a hydrostatic a hydraulic pressure source and increases from 0 to the maximum that is a maximum potential pressure within a period of 15 second. Maintain P max for a period of one hour for metal sprinklers and for 24 hours for plastic sprinklers. So, these are and the time duration which has been given for both types of sprinklers and then the procedures are explained, other procedures are explained in these steps.

Test for uniformity of rotating speed with the sprinkler mounted on the vertical riser operate the sprinkler at its test pressure and measure the time required for each quarter revolution separately means, it could be of one revolution how much time it takes. So, if one quarter it is taken and then the total observation it should be repeated for 5 revolutions then the average value should be taken and then accordingly, the per the test value, it is given this would be compared. So, extreme deviation from the average shall not exceed + - 12%.

Test of water distribution characteristics is done as per the specification so one need to find out the water application rate. This particular water application rate it should be within the prescribed limit and this is normally given for each sprinkler and that should match with the infiltration capacity of the soil.

$$h = V \times \left(\frac{10}{A}\right) \times \left(\frac{1}{t}\right)$$

So, this h is given, h is water application rate in millimetre per hour is given by the volume of water collected multiplied by 10 divided by the area of the collector opening that is can opening area and then multiplied by the 1 by test duration in hour. So, this will give us the water application rate in millimetre per hour. So, this we need to plot the curve for all the collector where the observations are made. And this particular observation it is a function of the distance of each collector and sprinkler along the placed along the radius.

Test of range for effective pressure this is another test which is recommended. So, this test before performing this test they keep the sprinkler immersed in water at 60 degree centigrade for one hour, then operate the sprinkler for 10 minute at the test pressure. We need to mount the sprinkler nozzle on the riser and then increase the water pressure from 0 to the pressure at which sprinkler begins to rotate steadily in one direction. Operate the sprinkler at this pressure for 2 minutes. Then we need to increase the pressure gradually and reach up to the maximum pressure then take the observation or once it achieved after a 1 minute, then find out the values repeat the test that is sprinkler inclined 10 inches from the vertical. So, this is at a particular angle of inclination the sprinkler shall rotate consistently in one direction throughout the entire range between minimum and maximum effective pressure.

So, we discussed about all those tests please refer these references, internet differences about these tests, these are available in bureau of Indian standards and also international standard organization that test code one should refer.

And then let us summarize this particular lecture. We discussed about the evolution of stability. We discussed about the duration as well as performance of the sprinkler irrigation system components according to bureau of Indian standards specification. In the forthcoming lecture we will discuss about solar photovoltaic system for irrigation part 1. Thank you very much.