Power System Protection and Switchgear
Professor Bhaveshkumar Bhalja
Department of Electrical Engineering
Indian Institute of Technology, Roorkee
Lecture 39
Testing, Commissioning and Maintenance of Relays-I

Okay, so let us discuss the topic that is known as Testing, Commissioning and Maintenance of Relays. So, now we know that the regular and systematic operation of protective device that is very important, because we know that most of this protective device, they operate only when fault occurs. So during normal condition, this type of device they do not operate. So, this is very important and very crucial that the actual relay operation during its whole life that is considerably variable very small.

So, if I consider 1 relay and let us say the lifespan of that device or relay is the 10 years, then within this 10-year span, this device may operate hardly 10 or 20 times. So, for rest of the period this device does not operate. So, that means it is very important as far as protective relay is concerned that it has to operate only in case of fault conditions and it cannot operate in case of normal condition, when there is no fault or abnormal condition, when there is any external fault.

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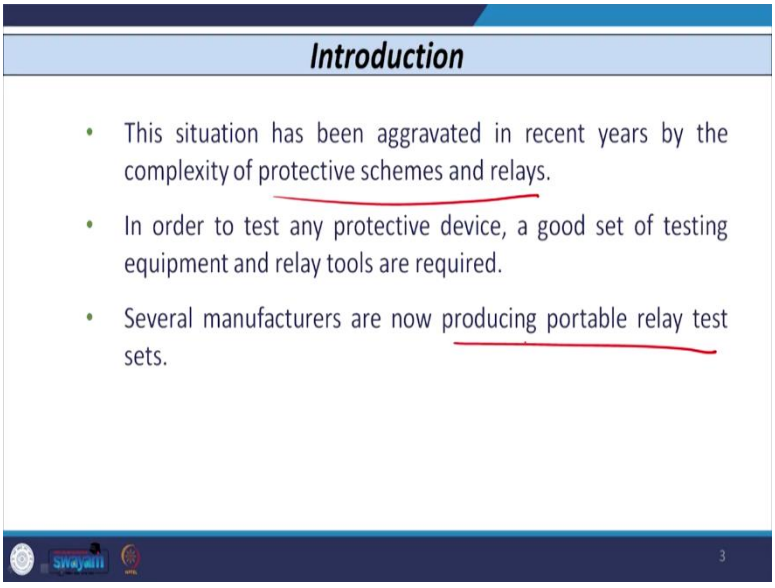

So, it cannot be readily tested under normal operating conditions. So, whatever the testing of protective schemes, that is always very important and crucial. So, we need to study what are the different tests that is to be performed on the protective device.

So, the situation that is aggravated in recent years by the complexity of the protective schemes. So, when we consider the protective schemes, we know that the digital relays are available and the circuitry of digital relays are very complex. So, the testing of such type of relays or such type of device that is very important and very complex.

So, in order to test any protective device, a good set of testing equipment and some tools are required. So, several manufacturers are now producing this type of tool through which we can carry out the testing of relays. This type of tools are manufactured by maybe Alstom, the other manufacturer is OMICRON, there are some other manufacturer also who is providing such type of relay testing equipment.

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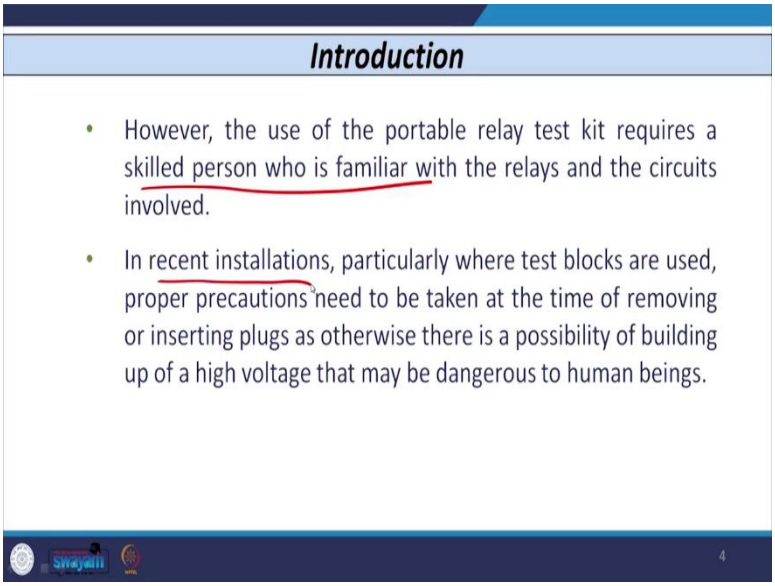

Now, we know that however the use of the portable relay test kit that requires a skilled person, because we know that whenever we use such type of relay test kit then we need to take some precautions. And also, we need to disable several contacts, we need to enable several contacts if we want, wish to carry out certain test. So, this is very important and that needs a very skilled person, a very, who has a knowledge of relay as well as the knowledge of such type of portable relay test kit. So, in recent installations particularly where the test blocks are used, proper precautions need to be taken at the time of removing or inserting the plug.

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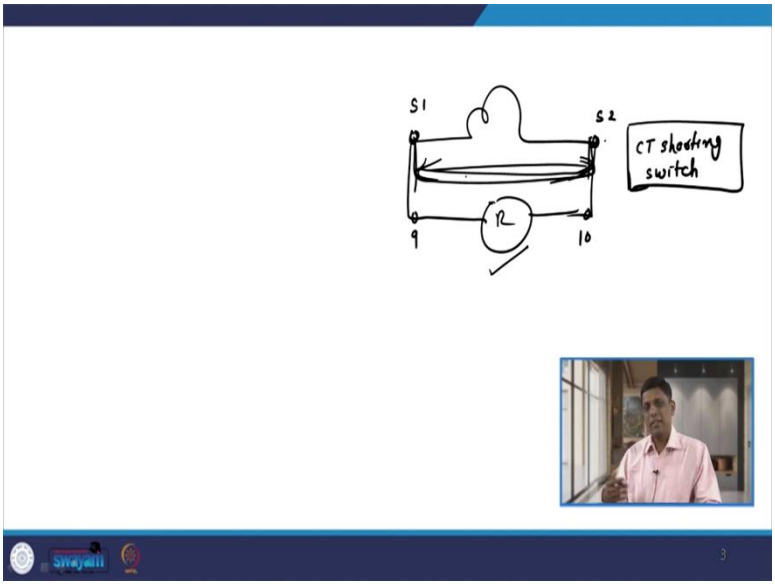

So, the main best example is, for example, we know that, whenever we use the current transformer, then we know that the relay that is always connected across the secondary of current transformer, if it is over current relay. So, this relay means it has a relay coil, let us say the 9 and 10 terminal that is connected with the secondary of this CT let us say S1, S2.

Now, when you connect the relay with the CT secondary, when you want to carry out the testing of this relay, you have to remove this relay from the panel. So, when you remove it, this CT secondary that should be open circuited. So, whenever CT secondary that is open circuited then the huge voltage that is developed across the CT secondary, which may endanger the life of the person working in the, as a operator in the substation.

So, to avoid that, whenever you remove the relay, you have to short the secondary of CT, because CT secondary should not be remain open circuited. So, this is done by CT shorting switch. So, normally most of the digital or numerical relays, they provide the device known as CT shorting switch.

So whenever you want to carry out the testing of the relays and whenever you remove it from the panel, at that time, the CT shorting switch comes in picture and it automatically short these secondary of CT, so there should not be any problem as far as the open circuiting of CT secondary is concerned.

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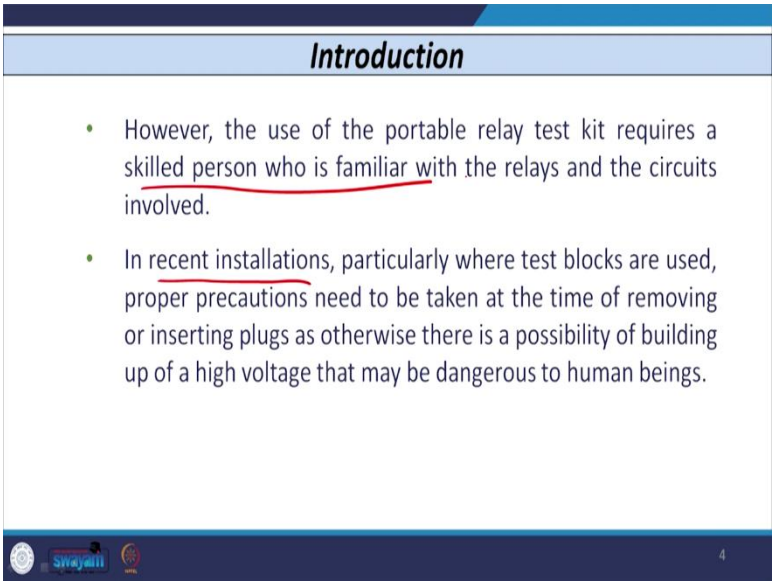

So, this is one of the precaution. So, similarly, you can, you have to take care of several other things also when you carry out the testing of release using some standard relay test kit.

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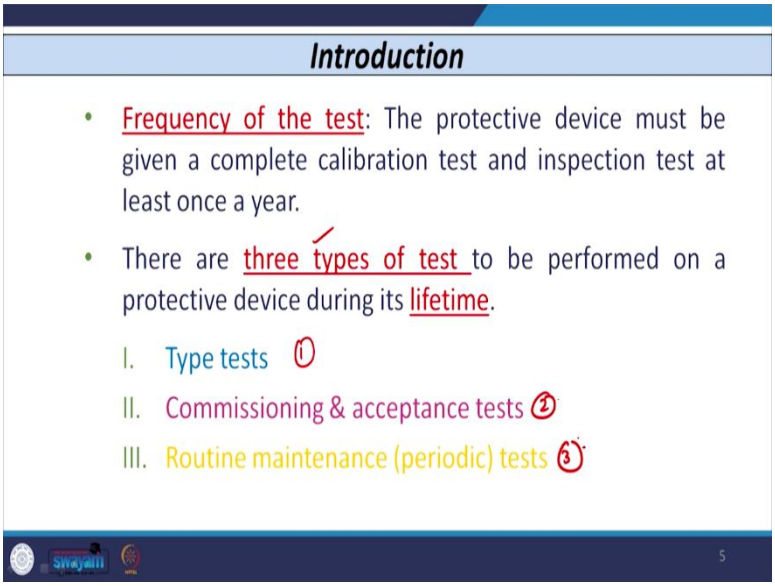

Okay, so let us consider the frequency of the test that is also very important because at what interval we need to test the protective device or relay that plays a very important point. So, protective device must be given a complete calibration test and inspection test at least once in a year. So, wherever we consider the different types of test that is to be performed on the relay or device, then usually there are three types of tests that need to be performed on the protective device during its whole life.

So, these test are, one is known as the Type test, the other is known as the Commissioning and acceptance test and the third that is known as Routine maintenance or periodic test. So, let us discuss each and every, these three tests one by one. So, let us start with the, how the type testing of the protective device that is to be performed or carried out.

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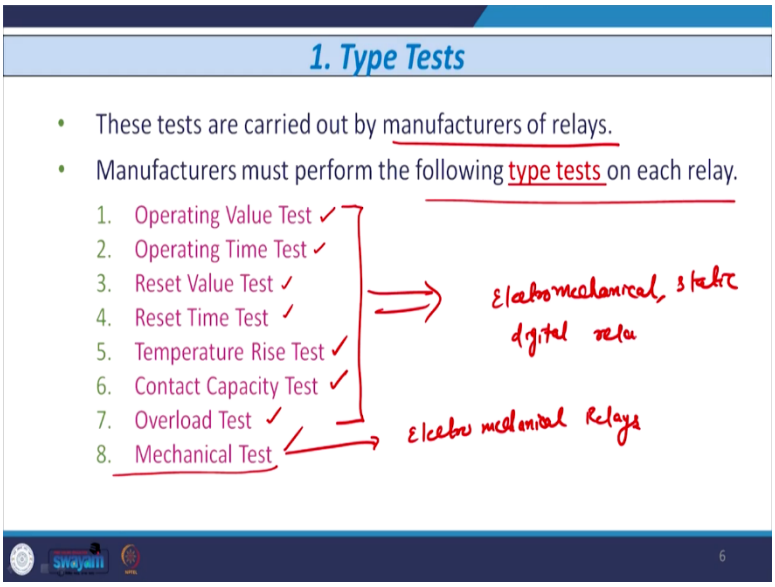

So, type test, that this type of test that is carried out by usually manufacturers. So manufacturers who are manufacturing the relays, they need to perform the type test on the relay or on the protective device. So, as far as type test is concerned, the manufacturer has to perform following type tests on each and every relay.

So, the first that is known as the operating value test. The second is the operating time test. The third is the reset value test. The fourth is the reset time test. The fifth that is the temperature rise test. The sixth that is the contact capacity test. Seventh that is the overload test. And the last that is the mechanical test.

This mechanical test that is performed only on electromechanical relays is not going to perform on all other next generation relays. So, this is only for electro mechanical relays. Whereas, the other rest of the this test that is performed on all electromechanical, then you can say static and digital relays. So, let us see these 8 tests one by one.

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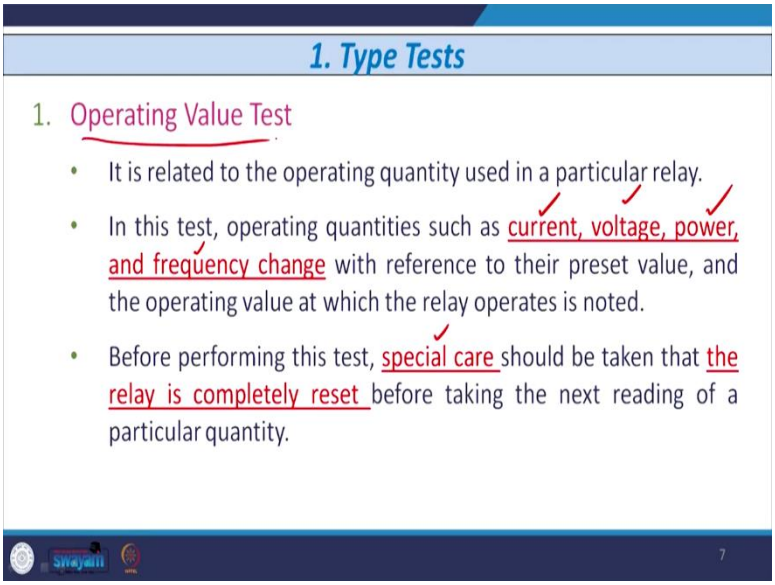

So, let us start with the operating value test. This is one of the type test. So, this operating value test is related to the operating quantity used in a particular relay. So, if I use over current relay, the operating quantity is current, if I use over voltage or under voltage relay, the operating quantity is voltage, if I use the low forward power relay, the operating quantity is power, if I use frequency relay then the operating quantity is frequency.

So in this test, the operating quantities, as I told you current, voltage, power, frequency, that is given are considered as a reference with reference to the preset value, and the operating value at which the relay operates that is to be noted down.

Before performing this tests, some special care that is required. The relay that should be completely reset before taking the next sample or next reading, otherwise you will have the wrong value, because once the relay operates, starts operating as soon as it is, when it operates and after that, it will come to original position.

So, before it comes to original position, if you start or taking next sample or interval next reading, then as relay has performed only half distance and again you start, so that will give the wrong reading. So, this is one care that you need to be required when you perform the operating value test.

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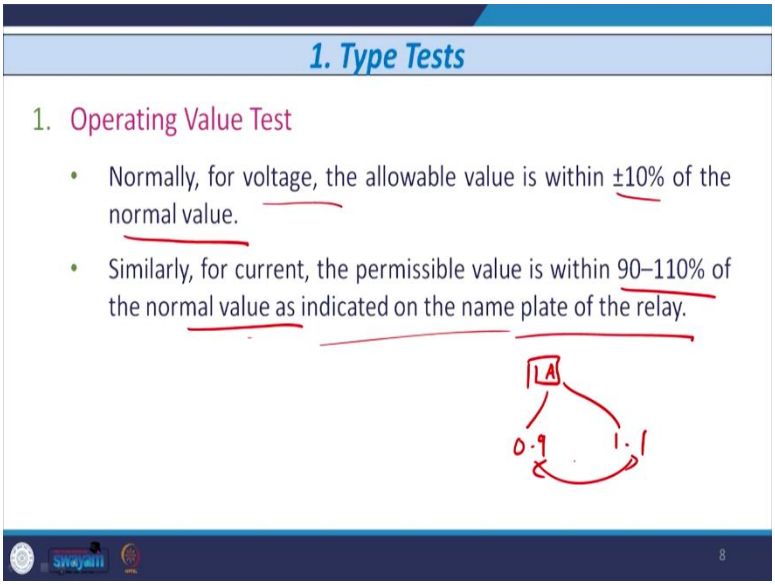

Now, when we consider the operating value test, there must be some limit for each and every quantity. So, if I consider the voltage, the allowable value that is within plus or minus 10 percent of normal value, and if I consider the current, the permissible value is 90 percent to 110 percent of the normal value as indicated on the nameplate of the relay. So, if I use current relay, then on the nameplate of the relay, the reference, this normal value is indicated and when you use voltage relay on the nameplate, the nominal value that is also indicated.

So, the variation allowed in voltage case is plus or minus 10 percent, in current cases, it is 90 percent to 110 percent. So, if for 1 ampere let us say is the nominal value in case of overcurrent relay, then the percentage allowed variation in this current that is 0.9 or 1.1. So, your value or reading that should come or fall under this band.

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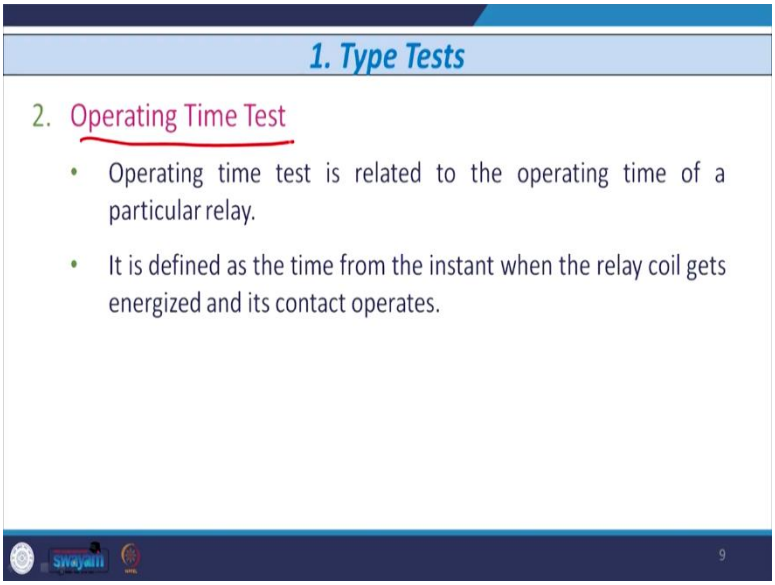

Let us consider the second one that is operating time test. So, this is also one of the type test that is to be performed by manufacturer. So, operating time test that is related to the operating time of relay. So, it is defined as the time from the instant when the relay coil gets energized and the time when the contact of the relay separates.

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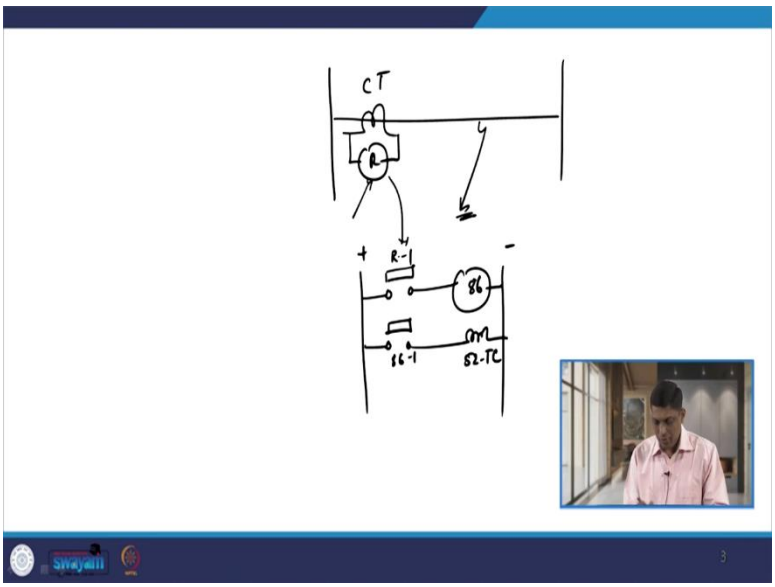

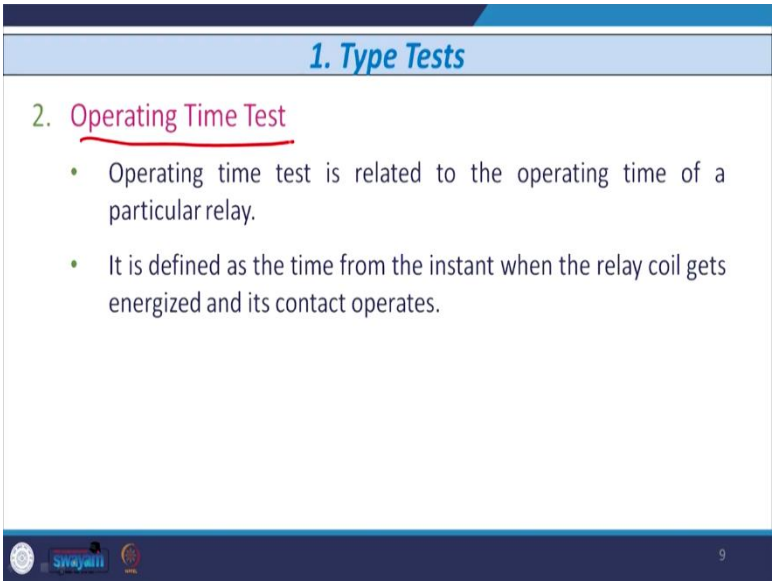

So, if I just tell you how this is done, so if I consider, say let us have, we have the relay that is located here. Let us say this is an overcurrent relay, this is CT and this relay has the, on the control circuit part it has the contact let us say the R-1, and then this contact is given to the coil of the auxiliary relay and then you have the contact of auxiliary relay 86-1 which is given to the 52-TC, that is the trip coil of circuit breaker.

So, this is your control circuit. Now, what is the operating time? Operating time means as soon as the relay coil that is energized say some fault occurs, the current is transferred on CT secondary side that flows through relay, relay coil is energized, and when it gives signal to this relay contacts R-1, that value that is known as the operating time of the relay. So, that for that we need to carry out the test that is performed by the manufacturer.

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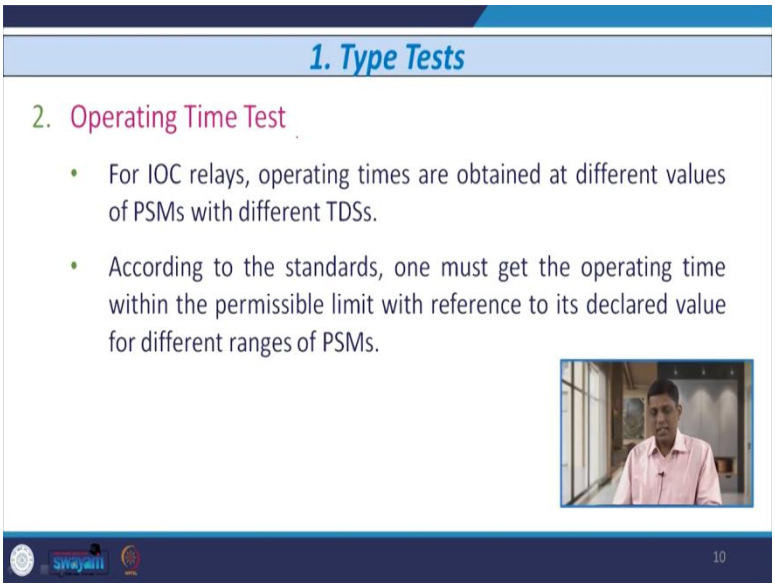

So, for all inversed and overcurrent relays, operating time that is obtained for different values of plug setting multipliers or multiple of pickup currents with different value of TDS.

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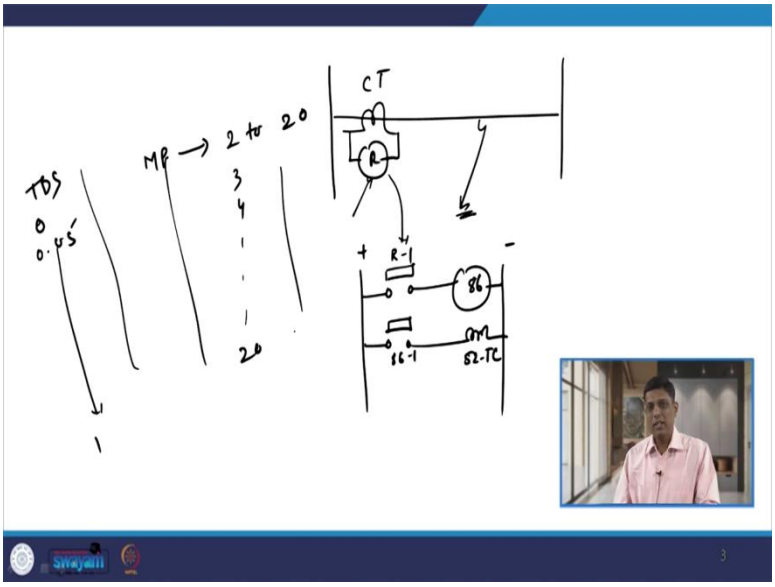

So, when you consider this circuit, what you need to do is your multiple of pickup current that is there. Let us say the value is 2 to 20. So, you have to take 2, 3, 4 in steps of 1 to 20. And then you have the other value that is TDS say 0 to 1 in steps of let us say 0.05. So, for all values, this two values, you need to perform you need to find out the operating value and then you need to check whether it is going to match with the nameplate on the nameplate they have given the graph, so you need to check it with the nameplate value.

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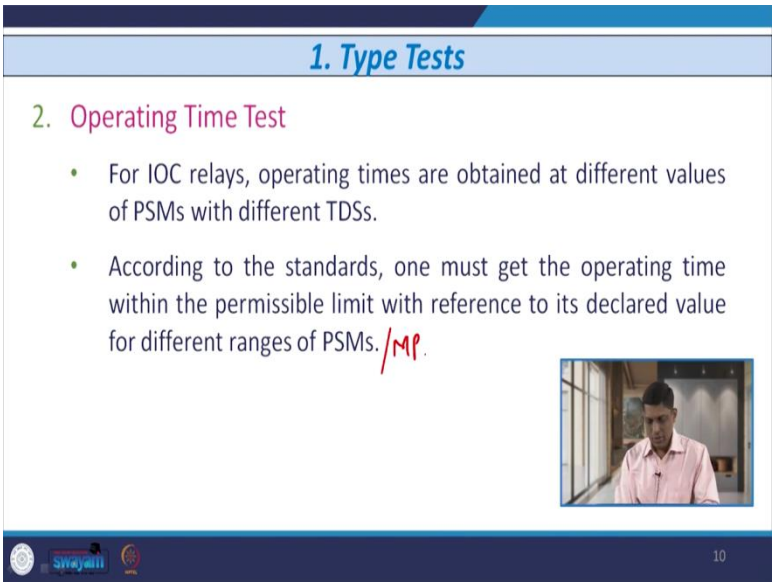

So, according to the standard, one must get the operating time within the permissible limit or range with reference to the declared value for different ranges of multiple pickup current or the plug setting multipliers. So, this is very important point.

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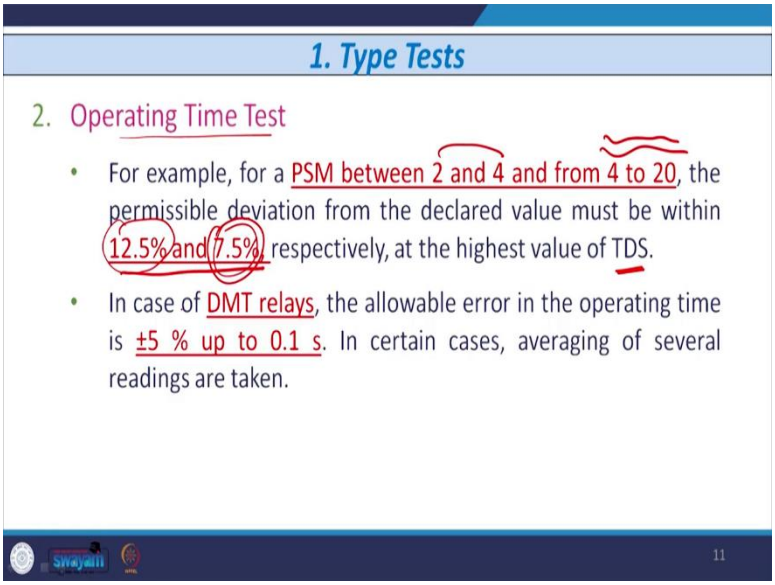

Now, when we consider the operating time, for example, the plug setting multiplier between 2 to 4 and maybe from 4 to 20, the permissible deviation in the operating time that is maybe 12.5 percent and 7.5 percent at the highest value of TDS. So, these two values, as I have mentioned for the PSM between 2 to 4, the allowable range for operating time tests that is this one, and for this value 4 to 20, the allowable range that is 7.5 percent. So, you can see that here if I vary the PSM between 2 to 4, the operating time variation in operating time that should be 12.5 percent with reference to the normal value.

Similarly, if I vary the PSM from between 4 to 20, then the allowable variation in the operating time that should be 7.5 percent of the norm nominal value. So, if I for example, if I consider the definite minimum time delay relays, the allowable error in the operating time that is plus or minus 5 percent say up to 0.1 seconds.

In certain cases, you can average it by considering say different number of readings, that is also the other method, but again the for each and every value of PSM or multiple of pickup current, you have some allowable value of operating time, it should not go beyond that range.

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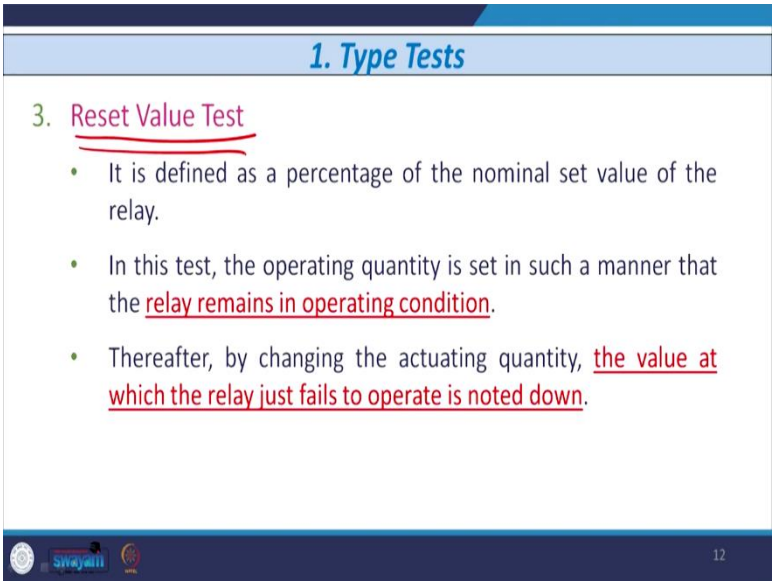

The third test that is known as the reset value test, this is also one of the type test to be performed by manufacturer. It is defined as the percentage of the nominal set value of the relay. So, normally in this test, the operating quantity that is set in such a manner that the relay remains always in operating condition. So, thereafter by changing the actuating quantity, it can be current, voltage, power, frequency, the value at which the relay just fails to operate, that is to be noted.

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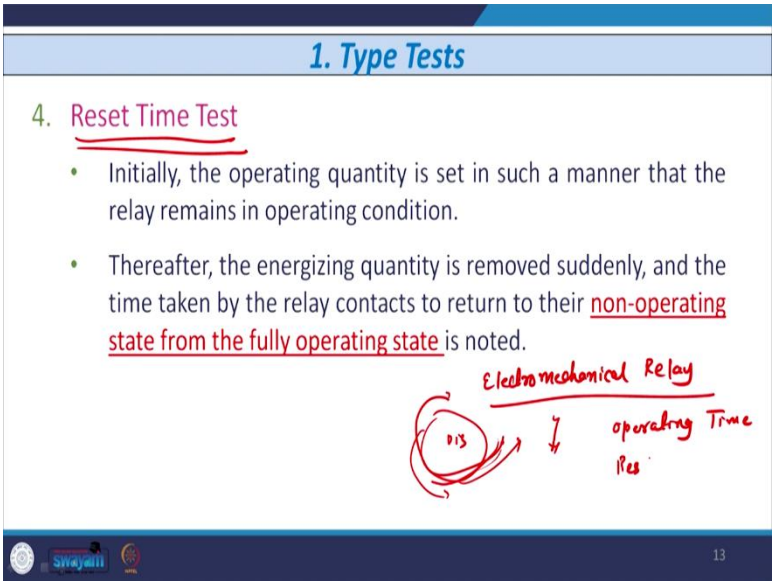

So, this is all about the reset value test and the next is related to same reset value, the reset time test. So, initially, the operating quantity is set in such a manner that the relay always remains in operating condition as I told you in the previous test, the reset value test. And thereafter, the actuating or energizing quantity is removed suddenly and the time taken by the relay contacts to return to its normal operating state from the fully operated state that is noted and that time is known as reset time.

So, you have to take the next ready once the relay fully reset. So, from wherever it returns to the normal operating state from the fully operated state that time is known as reset time. In this reset time, if I just consider the let us say electromechanical relay, then in case of electromechanical relay, if I consider that the let us say that this is the disc of the relay and it starts moving, fault occurs, the relay operates, the disc starts moving and after certain travel, the contacts of the relay operates.

So, this is nothing but your operating time of the relay. Once the relay operates, the current becomes discontinued. So, again this disc will move from this position to the original value. So, the time required from this point by the disc to come to the original position that is known as the reset time and there is a ratio known as resetting time divide by operating time, there is a ratio and this ratio should be as high as possible.

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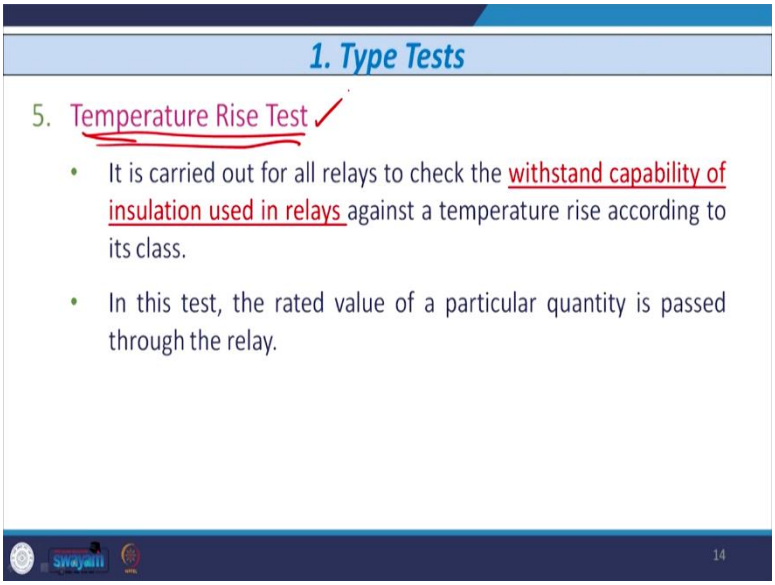

The next test that is known as the temperature rise test. So, this type of test is carried out in for all the relays just to check the withstand capability of insulation used by relay. So, basically we know that in relay whatever contacts are there, whatever coils are there that has to be manufactured or designed based on certain insulation class.

So, there is a need to check what is the withstand capability of the insulation used in the relay This is particularly with reference to the temperature rise. So, when you give the normal current or certain value of current, what is the temperature rise with reference to the current flowing in the context of the relay or coil of the relay, so that needs to be tested and that comes under the temperature rise test. So, in this test the rated value of current that is given or quantity that is passed through the relay and then the temperature that is to be note down.

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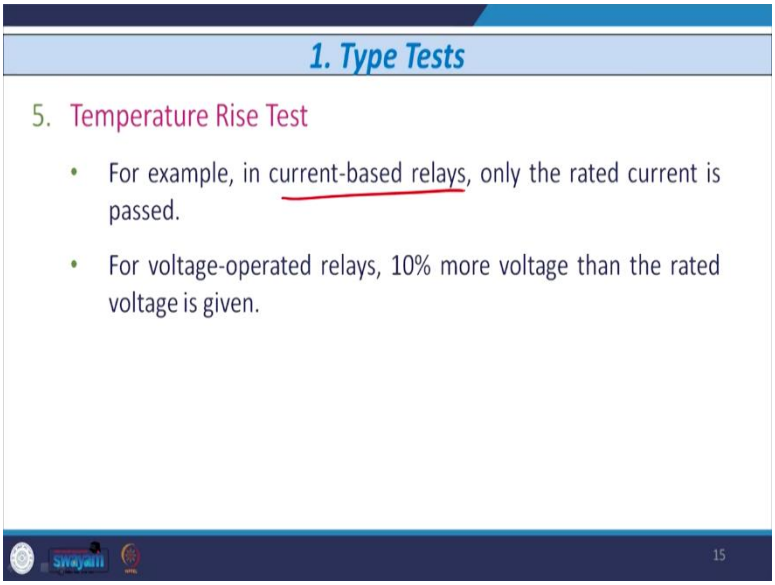

For example, in case of overcurrent relay, the rated current is passed through the relay and in case of voltage base relay. 10 percent higher than the nominal value that is given and the temperature rise that is to be noted.

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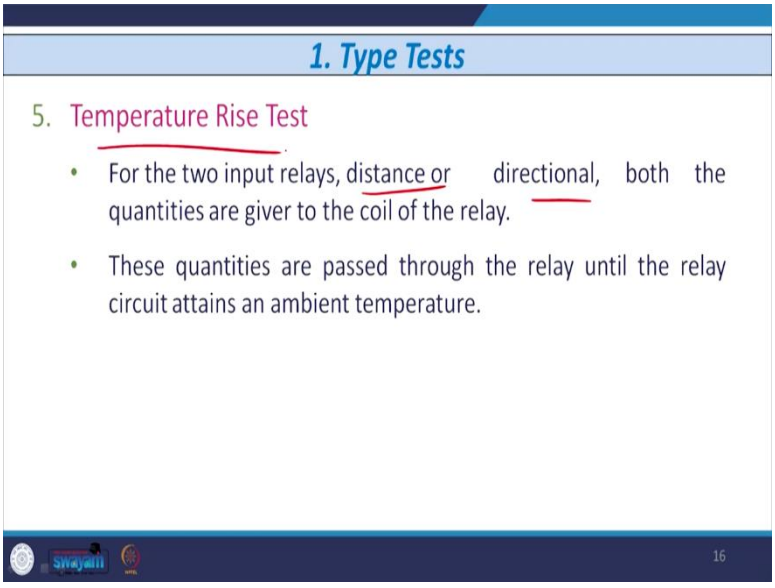

For two input relay like distance and directional, both the current and voltage quantity that is given to the respective current coil and voltage coil of the relay and these quantities are passed through the relay until the relay circuit attains the ambient temperature. So, this test that is again related to the temperature rise because of the quantity that is passing through the coil of the relay.

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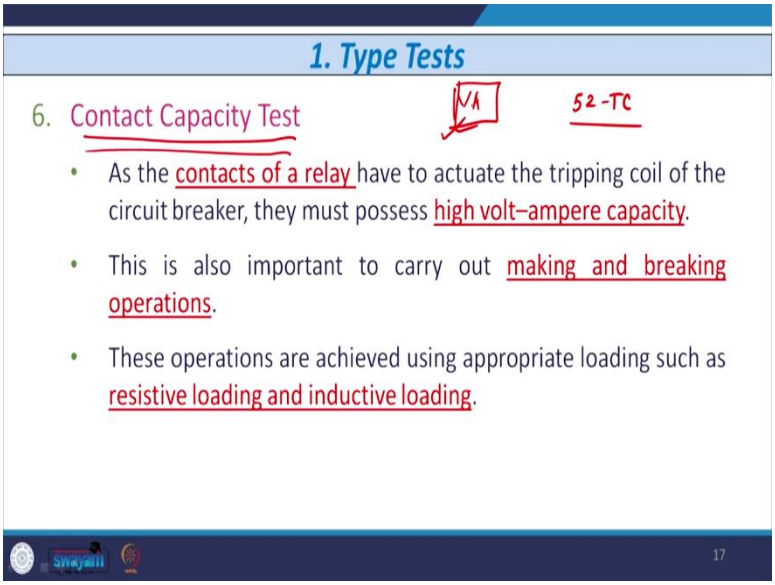

The next test that is known as the contact capacity test. So, we know that the contacts of the relay, have to actuate the tripping circuit or tripping coil of the circuit breaker as I told you it is 52-TC, that is the trip coil of circuit breaker, 52 is the number given to circuit breaker. So, contacts of the relay have to actuate the trip coil off circuit breaker So, they must possess high volt ampere capacity so VA capacity of the contact of the relay that need to be defined by each and every manufacturer.

So, this is also important to carry out making and breaking operations by this relay contacts. So, if relay contacts is normally open, then whatever how many breaking and making operations that is performed by this contact that need to be defined by the manufacturer. So, these operations are achieved using appropriate loading such as you can use resistive loading, you can use inductive loading. Normally inductive loading that is used, the resistive loading is not used.

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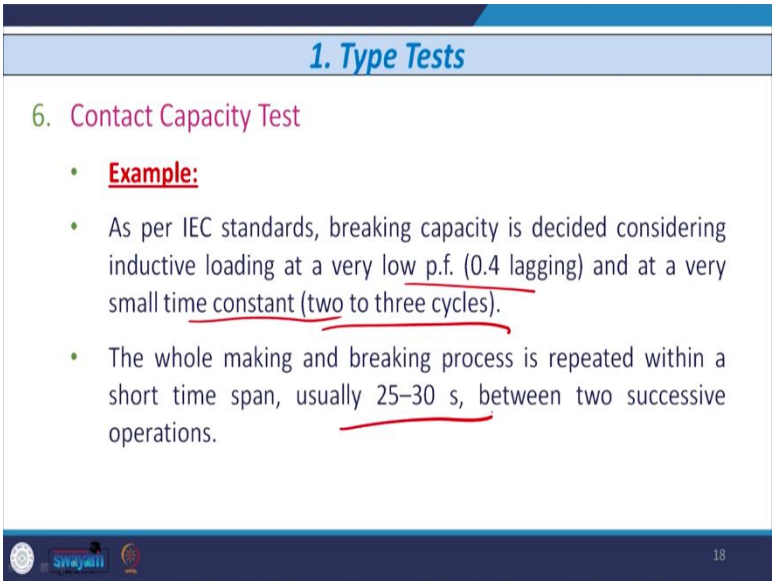

So, for example, as per IEC standard, breaking capacity is decided considering inductive loading at a very low power factor say 0.3, 0.5 and a very small time constant that is 2 to 3 cycles. In this standard, they have defined that when you carry out the contact capacity test, then how you need to what conditions you need to create. So, the power factor should be very low and the time constant should be also very low first two, three cycles immediately after the point that is very important.

So, the whole making and breaking process is repeated within short time span, usually 25 to 30 second between two successive operations. So, this is how the contact capacity test that is to be performed.

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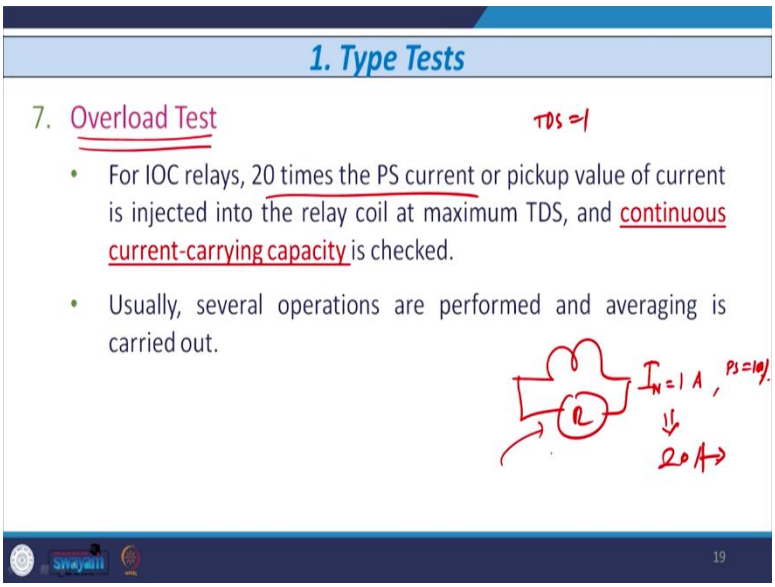

The next type of test that is known as the overloading test or overload test. This is also of the type test that is to be performed by relay manufacturer. So, for all inverse time overcurrent relays, normally 20 times the plug setting current or the pickup value that is injected into the relay coil with the maximum value of TDS. So, TDS is 1 in this case. And the continuous current carrying capacity this coil or contact that is to be checked.

So, what you have to do is you have to whenever you correct the CT secondary, you have to inject let us say the nominal current is I nominal, that is let us say 1 ampere. So, on CT secondary, you need to inject the let us say the plug setting is 100 percent, so you need to inject 20 times the plug setting current that is 20 amps current on CT secondary and then you need to check the continuous current carrying capacity of the this relay coil and as well as the contact. So, usually several operations are performed and then finally everything that is to be carried out.

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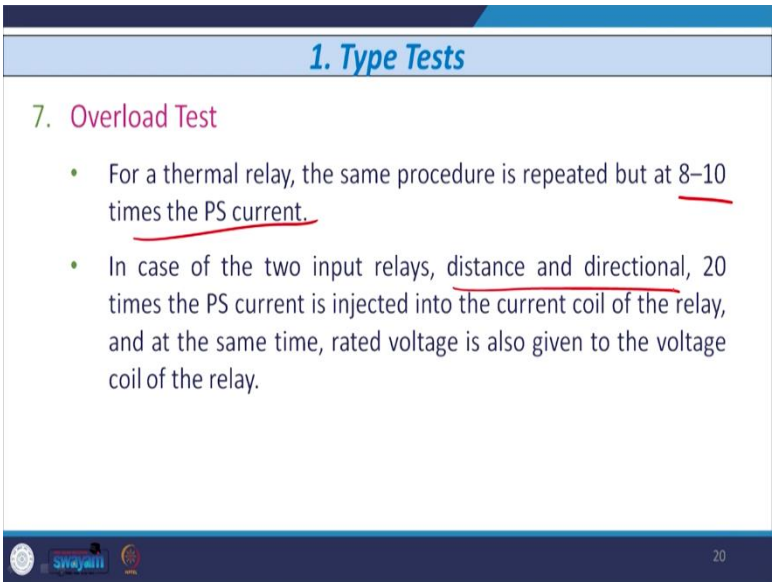

If I consider thermal relay, then the same procedure is repeated but at 8 times to 10 times the plug settings. So, again in previous case the current is 8 ampere to 10 ampere, that is for thermal relief. So, in case of two input relay, that is distance and directional, again the same value as we did in case of overcurrent relay, 20 times the plug setting that is to be injected to the current coil of the relay and at the same time the rated voltage is given to the voltage coil of the relay and the current and TDS current carrying capability that is to be checked.

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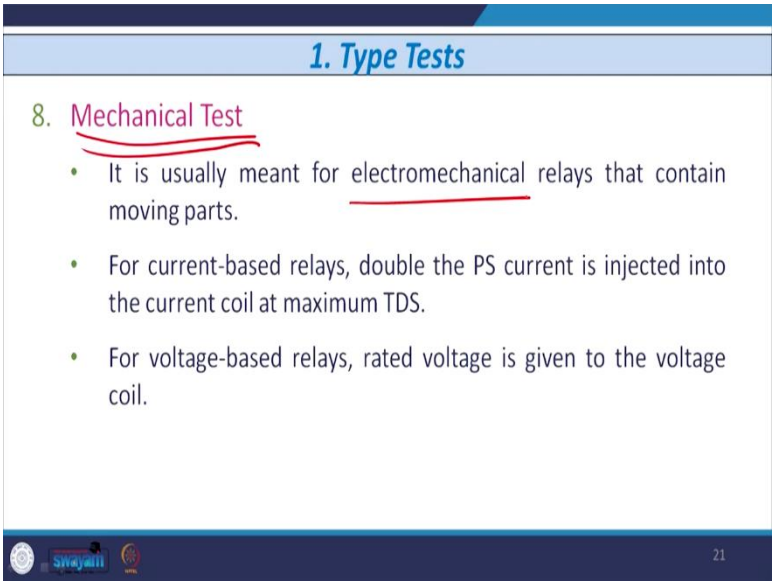

Last type of type test that is known as the mechanical test. So, mechanical test as I told you earlier, this is performed only in case of electromechanical relay. So, because that contains usually moving parts, rest of the next generation relays like static relays, digital relays and adaptive relays and other relays, they do not contain the moving part. So, this type of test that is not performed on the next generation of relays than the electromechanical relays.

So, for current base electromechanical relay, double the plug setting current that is injected into the current coil at maximum TDS that is TDS equal to 1. And for voltage base relay, the rated voltage that is given to the voltage coil of the relay.

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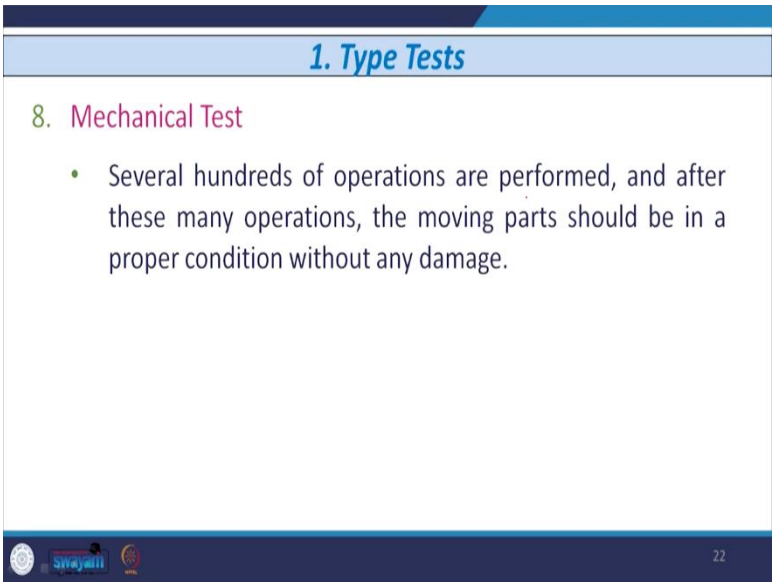

Several operations are performed and after so many operations moving part should be in proper condition without any damage. There is no damage on the moving part, any of the moving parts of the relay, that need to be noted. And hence, this is how the moving mechanical test that is performed on the moving parts of the electromechanical relay.

So, this is all about the type test that is to be performed by the manufacturer on the relay. Now, as I told you earlier, there are some other tests also that need to be performed. So, if I just again list out that value, then you can say that the first is the type test, the second test that is the commissioning and acceptance test. So, let us understand what is the meaning of commissioning and acceptance test.

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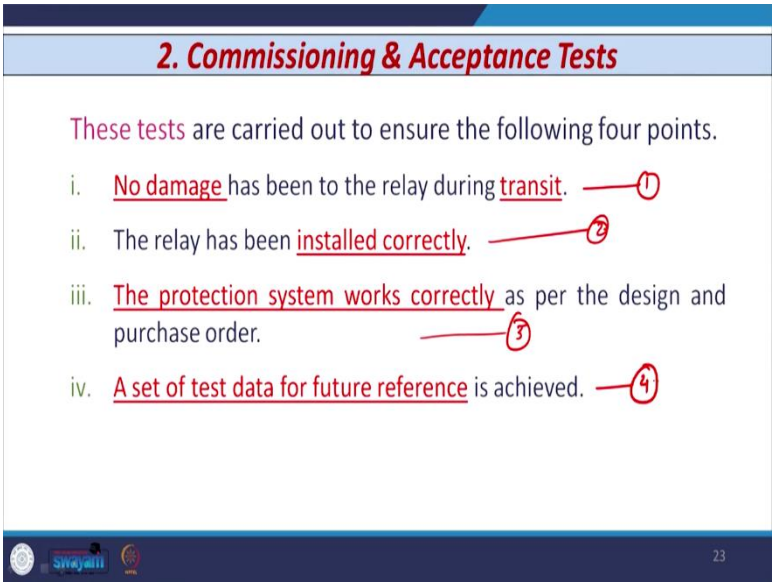

So, if I consider the commissioning and acceptance test then this test has to be carried out to ensure certain conditions or points. The four points are very important. The first, there should not be any damage to the relay when the relay is in transit. I procure the relay, I have given the order to the manufacturer, manufacturer has manufactured the relay specific type of relay and they have performed all the type tests which we have discussed, all seven, eight types of different tests they have performed.

Finally, the relay passed in all the tests and then that relay that is sent by the manufacturer. And whenever this relay that is in transit or transportation, there should not be any damage to the relay. So, if we want to ensure that we need to carry out the commissioning and acceptance test, whenever we receive the relay. That is one thing.

The second point that is the relay has to be installed correctly. So, as soon as I receive the relay, I have to install the relay, I have to perform the I have to check certain timings and all that on the relay. So, operating time, operating current need to be checked and I have to perform the operation of the relay as per the that is given on the nameplate of the relay by the manufacturer.

The third thing that is very important is the protection system works correctly as per the design and the purchase order. So, whatever design parameters I have mentioned in the purchase order, according to that the manufacturer has to manufacture the relay and the relay has to pass all the type test.

And then, whenever I receive it, I need to ensure that whatever relay I am purchasing with the from the x manufacturer, that relay that need that has to be installed correctly and that has to be performed correctly as per the design and purchase order that is mentioned various parameters mentioned in the purchase order.

And the fourth point which is very important, that is the, a set of test data for future reference. So, if I want to generate or build certain reference data for future testing, then also I need to carry out the commissioning and acceptance test on the relay.

So, in this class, we started our discussion with the different types of tests to be performed on the relay by various manufacturer. So, we started with there are three types of tests, one is type test, second is commissioning and acceptance test and the third is the routine maintenance test. So, we have already discussed the different type test to be performed by manufacturer before sending the protective device to the customer.

And then we started our discussion with the commissioning and acceptance test that is to be performed at the customer site or customer premises. The different tests to be performed under commissioning and acceptance that we will discuss in the next class. Thank you.