Electronics Equipment Integration and Prototype Building
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Lecture - 24
Analogous Mechanical – Electronics detailing

Allow me to continue where I took a small what you call interruption yesterday due to or length of the recording; this is continuation of earlier presentation regarding how allowances and tolerances are very very critical in relation to engineering drawing.

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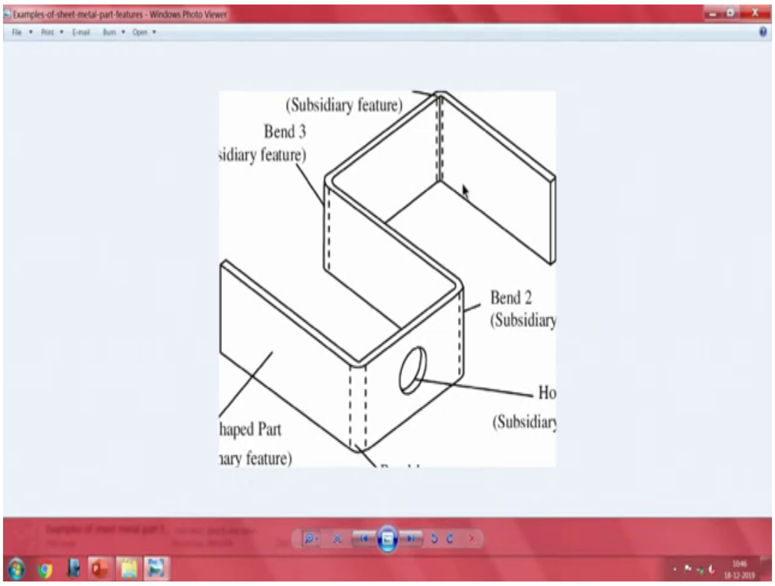

Now, say I will switch this on to you, this is a very routine bracket which we often see in our normal what do you call production or maintaining geometrical integrity with respect to all the parts.

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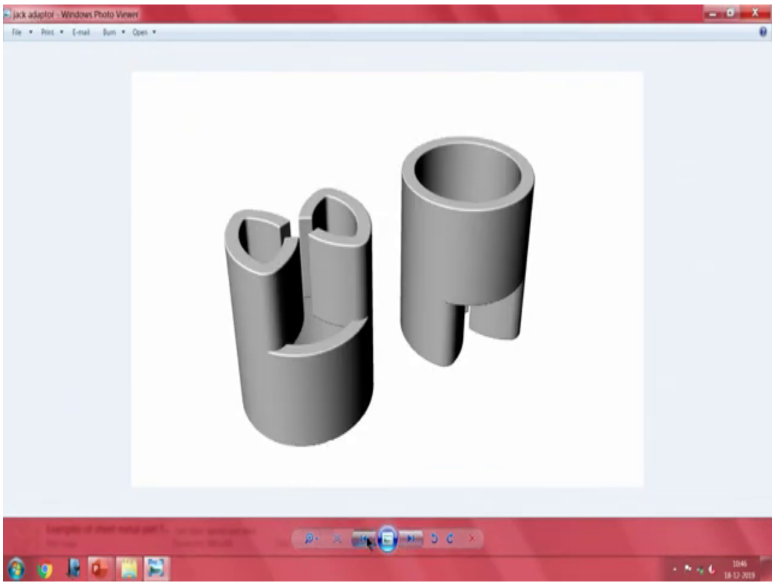

It looks relatively simple, because it is easy for me to you know what you call make something in depending on the total amount of number of drawings and all that.

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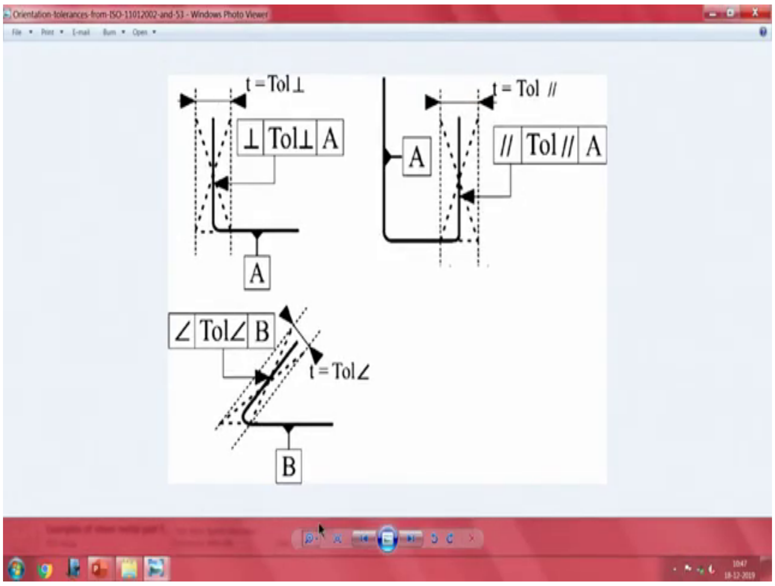

We can, I am sorry number of bends which are to be incorporated, we can mention it directly here. Now, we come to a very important thing regarding, the quality of the work. One part of it which I have spoken to you is about simple tolerancing; tolerancing we know is all about how to maintain one particular feature and then during production how variations occur, it may be because of tooling and because of other things like that.

However, you need to mention these things as per a international standard; the presentations here are as per the ISO and more or less everything is maintained. You see here there is a reference to a part A there is a perpendicularity symbol here, there is a parallelity symbol here; again recording to the particular features that is presented here. So, when you make the solid model, we have no issue with that; the models get easily done.

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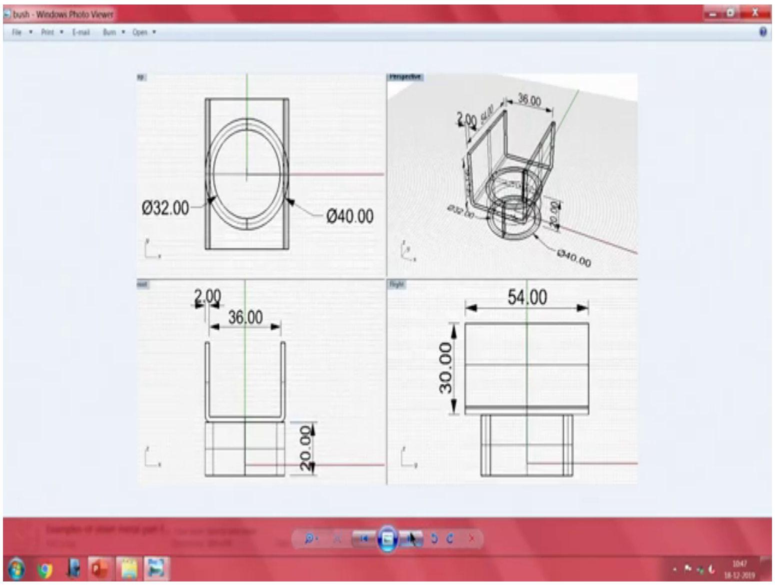

So, I will present with to you, a model which has been made here. It looks fine, is it not; all I wanted was saying, there should be a bush at the bottom portion, this is the bush.

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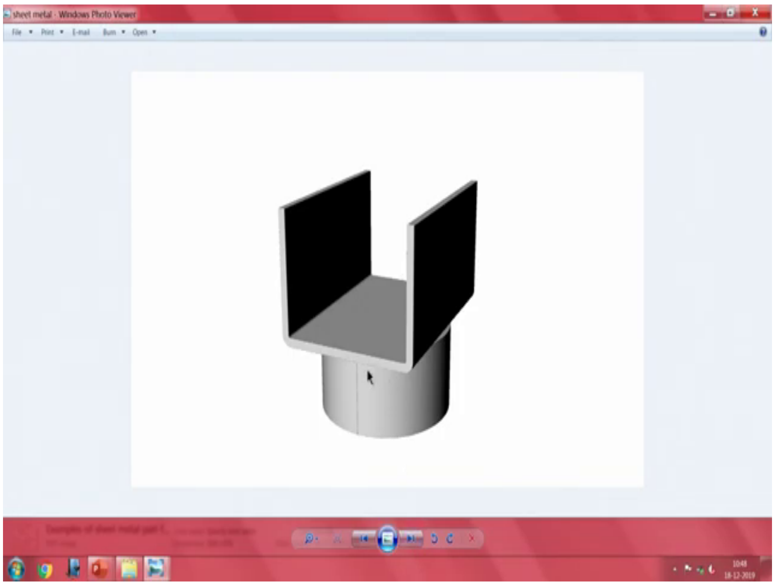

And then after that this is part of it is the bush, this bush should accept a plunger. So, for the while I will ignore the 0, 0 what do you call the two decimal accuracy. It was you know default, so I left it like that; most packages know they give this a default, because they were all based on the old inch dimensioning, where it was very very critical. Because it is very normal to go up to 64th of an inch or 38, what do you call 1 by 32 of an inch leaving all that; you will discover that in this particular case I was trying to make a part like this, looks fine is not it.

But this is where we end up with saying, is it enough if we just to make a model and live it like that and can anybody actually make anything like this. See here very nicely 54 is shown, there is something called 30 is shown and then if you go to this quadrant here, life cannot be better.

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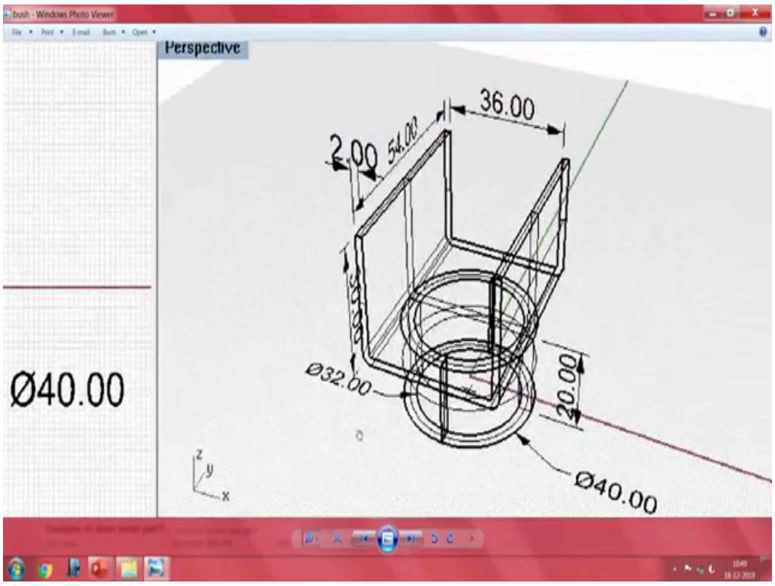

But in reality it is not so easy, please have a look at the part that has been fabricated.

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This is actual part that has been fabricated in the workshop. One of the first thing you will see is, this face that has been made here has been made by a different technique completely. So, what has been done is, a regular full-fledged solid has been taken; understand know, it is now at part of two parts that are assembled together, this whole thing has been machined from a full solid. Something of equivalent, right now I think this one was a 45 mm square ; so they have taken the 40 mm 45 mm square, they have made a they have build a group, then on the other side they have made a step here.

So, that the idea being, it sits on this hydraulic jack; this is part of a vehicle design which I will show you afterwards, the chassis member sits here. Same thing here with the other thing and then you will see here this just for the you know convenience saying how these things work and all that; and why these two have been shown is, this is a highest position, this is a smallest position.

Depending on the amount of raise you required, this is part of a what do you call the vehicle chassis. So, this has been kept under an electric vehicle chassis and then you jack it up. Once you operate this hydraulic jack, it has to be raised to this much to make sure that this top member engages with the chassis member; and then afterwards lifts the wheels clear of the floor and afterward some other safety backup support is there.

Now, that you have seen the whole; so if you see the drawing, it is not enough if I just mentioned some dimensions here. Two things are very very critical saying on what basis I have a calculated the depth 30 millimeters. This is only a concept drawing as such you know; when I actually it went to the workshop, the machine shop, somebody there has considered the type of material that is available, the type of material that is used and various strength aspects.

While I was feeling very thrilled that, I made a very good drawing here; you will first thing you will notice is, it is probably inappropriate to take a channel and try to take another pipe make you know two operations and then try to weld this things here. Or I tried to weld these things all around and may or may not give me a useful product.

In contrast what has been made there is, it strictly follows a practical approach; meaning somebody has measured all the necessary items and they have fabricated this end that is you know much more appropriate and it is strong end accidentally does not create any problems.

In this case let us say by some mistake, this thing gets squished together; the moment they gets squished together, we end up with a useless part. Similarly in the there may be a parallelity and such problems; but the design that has been implemented finally, there need not be a problem. The advantage being right now is, once I make the solid model, somebody can remotely work on it; the machine shop people can happily work on it and then get these things ready.

And then out of my unending enthusiasm, I have even tried to make something else; why not take a pipe of a correct diameter, because they are all standard diameters of a higher gauge and then just make a slit here, make a slit here and then build them together. Once I bend them and make them together, I expect this thing know it will make a very good what do you call a device on which I can make a u and put it.

But you too would have noticed, what is the point, what are you trying to prove here; saying except that you know how to make a solid model, it does not I mean are required nobody has seen an a utility of this product. You seen my point, then where do we have the u can I make something out of you; at that point we decided to just leave it saying, do not worry about any of these things, how to make this? This I have shown you earlier.

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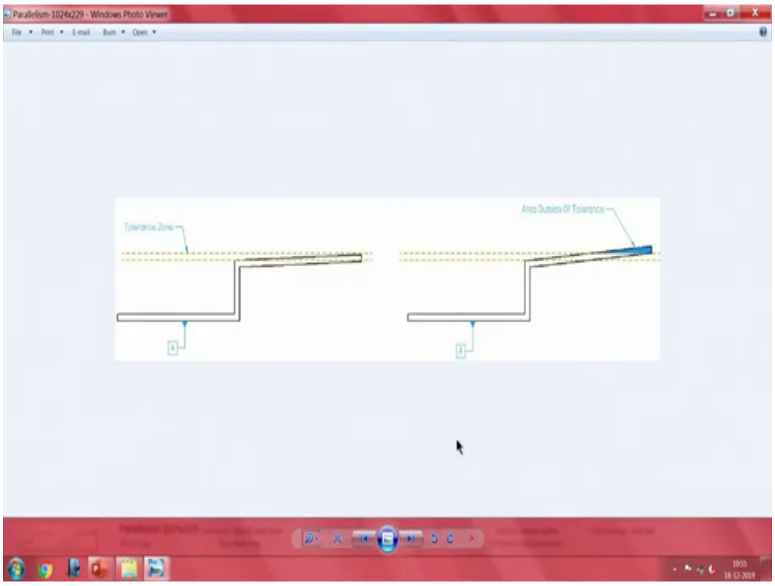

Now, especially in the case of sheet metal, the ISO has spent huge amounts of effort and documented; strictly speaking something false in the tolerance zone and then this is above the what I call a tolerance zone. Imagine one end of it falls within here, another end falls here; now do I accept a part or not that is where things like parallelism and other features are presented very well here.

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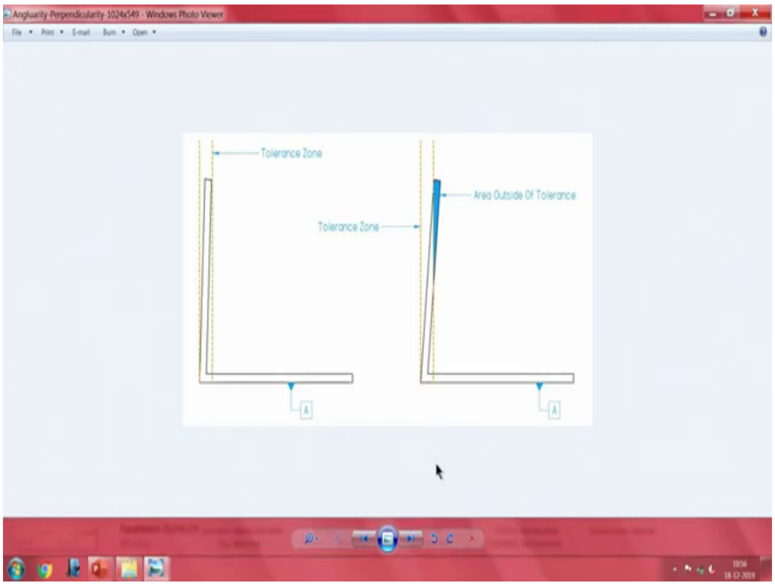

There is the tolerance zone, something has fallen out of sight. Imagine somebody makes a part know one end follows the one edge of it and another end follows the edge of it, will you still accept it or not; this is where things like perpendicularity and parallelism are stressed regularly. And the magic is, a simple solid model very rarely seems to take care of these things; you have got my point why I specifically picked on this is, a simple solid model make something which looks exotic and so on.

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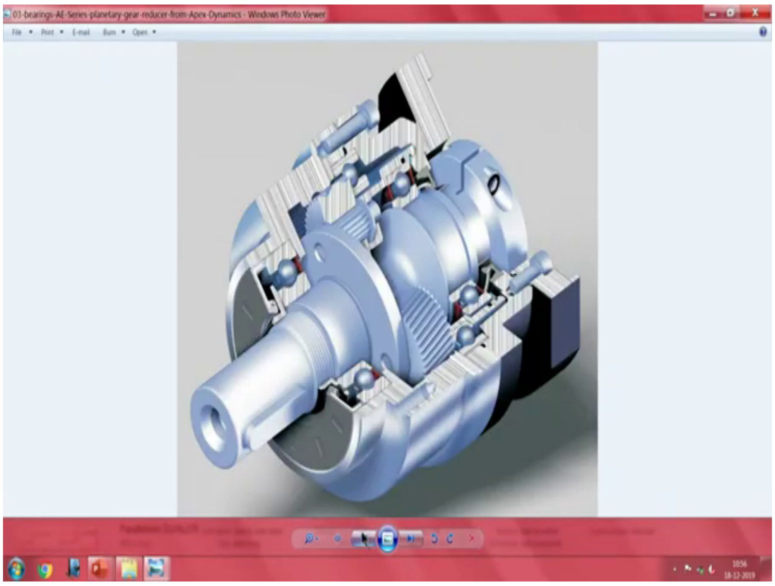

But in practical operation depending on the processing and all that, one needs to work carefully towards how these things actually what. This has been so far regarding the sheet metal work.

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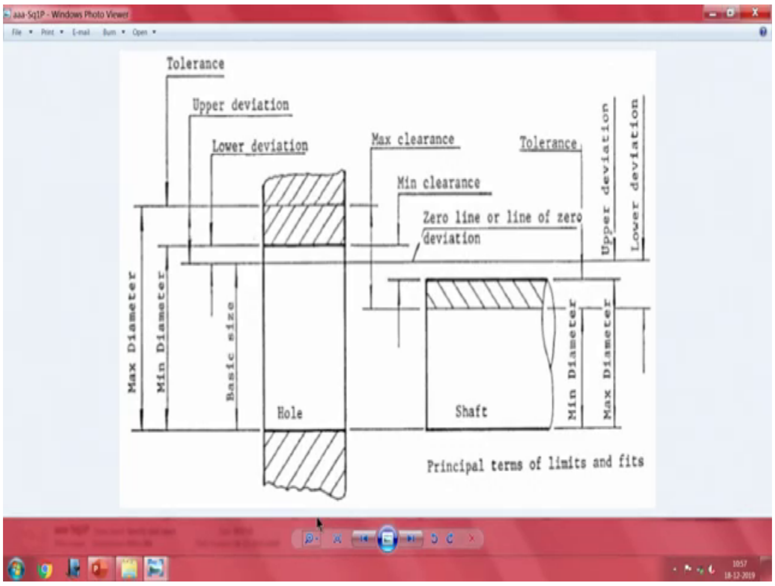

But if you see carefully this whole concepts of limits, fits and tolerances have derived from circular parts, typically bearings. This appears like a repetition, but kindly bare with me; because even earlier lecture know I started with this. At one point you have the practicality of there being a plug or a positive part which has to go into a negative part.

Typically, imagine if this were to be a pen, you have a cap and going in further imagine if this is going to be a ballpoint pen and in case of a ballpoint pen the refill has to go inside. So, specifically every type of refill, every type of pen these the allowable variations in production are mentioned here.

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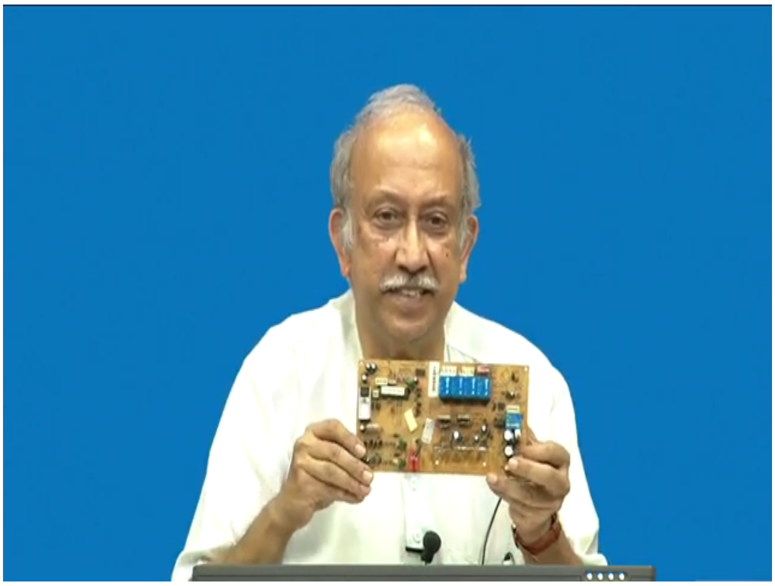

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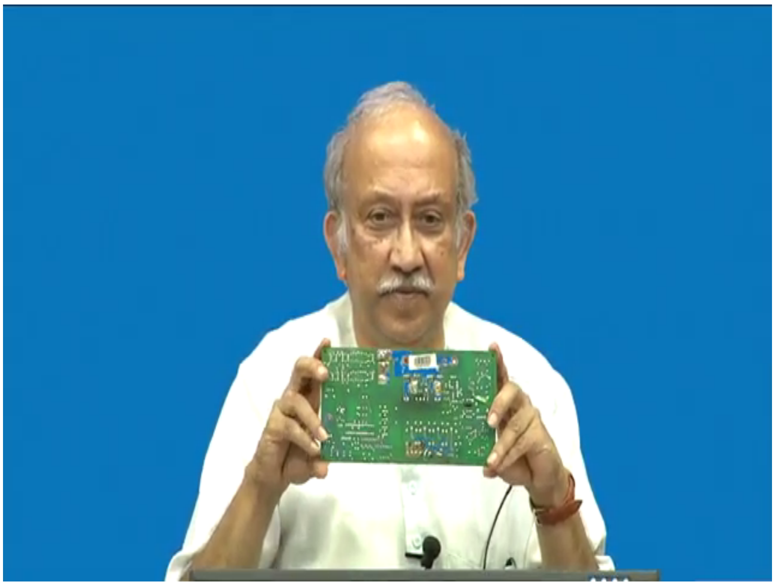

Now, what do we talk about this things, once in a while I gather these things, while it does not look very attractive; the reality is this whole thing has been mounted with four holes on one side. And again coming back to the features on one side, at one corner here we have a heat sink and there are mounting holes on the heat sink, there are two mounting holes and the heat sink goes and then all these power devices are supposed to get assembled on the heat sink.

And they share a common what do you call a base which has to be fixed here. Now this is where the process planning also comes in picture saying; do we first mount all these things and then tried to push them inside, alternately do you push all of these thing inside and do everything and then how do you assemble this screws and all that.

So, for this standard practices are there and standard jigs and fixtures are there. So, typically most likely that these all these power dissipating components are probably mounted on the heat sink upfront, and they are all aligned with respect to something which simulates the pitch of this screws here. You have seen here; if you see the pitch of these what do you call leaded laid in whole components, and imagine you take a another metal plate or anything, drill all the holes, you can push all these power devices into that.

And then align all of them, then mount these; I do not know whether there are transistors or thyristors, you are mount them inside. Once there all aligned perfectly, then naturally they go off into this, which is part of the design process. While the first ten lectures spoke a little about how the ways they try to just conceive a product and push it down; from the second set talks a lot about how to make them manufacturable.

So, specifically I have given this example of saying, we have five different loose components which have to be mounted on a separate mechanical assembly and all of them have to go inside. Fortunately for us we need not worried too much about it; because there are process planning people who know how to handle these things. Most likely they have already fixtures or jigs to hold these things. Single component there is no issue about it, there is a single component which is mounted directly until small heat sink and at the back the same mounting hole which is used for mounting the power device onto the heat sink is also used for mounting this inside.

Now, comes to why I continue to show these things are, we have several other things; there is a small header here which is part of a connector, there is one more here and there is one which is very close to here and there are some little larger power connections here, all of them are once again mechanical items and this is where the criticality comes.

How well, how do you mount all these things, how do you position these things on the PCB; this is where I feel our course and let us our registrants to this course will benefit a lot, if upfront you sit with the designer of these or fabricator of this PCB and find out typically how well it is convenient for us to use it. In this case fortunately there are no trimmers and such things that need to be adjusted; but however, all this stuff know has to now align itself to an enclosure outside, where you probably need access inside.

Look at it here, one more time I have ended up with, why I have found this same volt to peculiar some device here which I do not know, if it is a fuels or it is a some gas discharged device or something like this which probably you need an access to it from outside; such that when you wanted you can isolate it or when you do not want it you can remove it, right now it is frozen, I leave it like this later on I will tell you. Most likely it is a some sort of a device for which need a access.

And by definition this is not a user service well things; in case something goes, the whole module little bit taken inside, somebody has open it, probably they have a screw here or some device to clamp it and remove it outside. This is where extreme thought and interest is required for us to make these things.

And then I will again draw your attention to for small diodes which are mounted here, for divots. Generally in the case of these devices, the heat conduction is probably through the leads; however, due to some I do not know peculiarity of this, they have provided a small slot here. A small slot probably helps in a little bit of air circulation or it prevents sharing of these diodes; I mean charring of the PCB and diodes in cases some failure.

Similarly, you have seen this, there are very large tracks pads and all that here; all these large tracks and pads need to be reflected in your model. So, it helps if you try to start your solid model including these things like power components; while in that case of a routine small device they are may not make too much sense. In the case of our little larger things wherever a current of more than 1 amp is involved and you have large electromechanical device, there is a bank of relays.

And these bank of relays it says of course, it says 7 amps, 7 amps is not a DC braking, neither it is service rating; it is just a some nominal rating and the person uses it, it knows what to do with it, but it can safely carries 7 amps. So, once we circuit a switched and it can continue to carry 7 amps without any problem; provided it within the voltage setting and within that what do you call other specifications which are mentored here.

But most important is what is the spacing you are required to be kept and secondly, do you need some a little bit of circulation and does this become hot. In case this becomes hot, any other component here by radiation will probably pick up the heat from there. These come over the years by practice and each industry and each field have standardized on these practices.

You have seen why I am repeating it is, this in spite of his being a simple electronic circuit and based on a simple circuit diagram, you will notice that; eventually when it takes a physical shape, all these have to be considered. And very peculiarly I do not know meant for various other reasons, probably involving soldiering, probably involving shrinkage, involving wicking and wetting of the various solders various types of thermal bridges as well as dams have been built inside.

If you give a gap, heat would not be shared; if you just leave a solid copper area, in this case the current will be shared. So, these things have all to be considered when you are making anything which is bigger than a normal simple 1 amp circuit.

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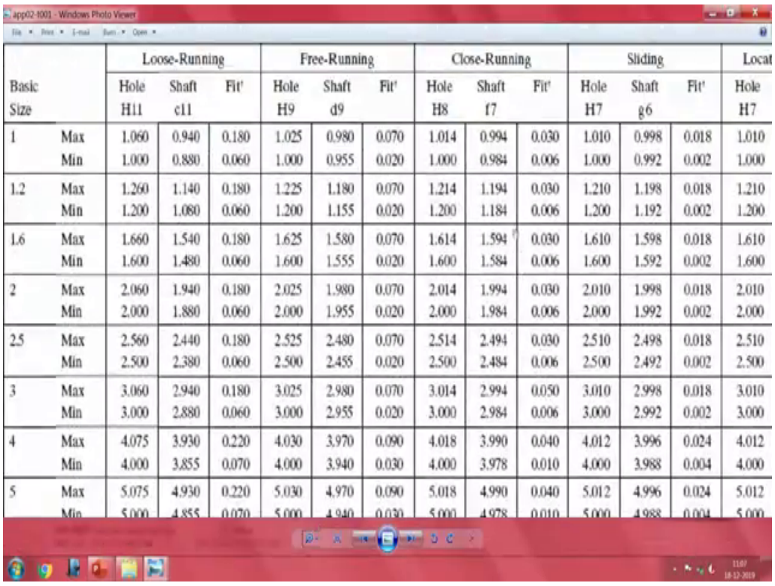

Basic Size		Loose-Running Hole H11	Loose-Running Shaft c11	Loose-Running Fit'	Free-Running Hole H9	Free-Running Shaft d9	Free-Running Fit'	Close-Running Hole H8	Close-Running Shaft f7	Close-Running Fit'	Sliding Hole H7	Sliding Shaft g6	Sliding Fit'	Locat Hole H7
1	Max	1.060	0.940	0.180	1.025	0.980	0.070	1.014	0.994	0.030	1.010	0.998	0.018	1.010
	Min	1.000	0.880	0.060	1.000	0.955	0.020	1.000	0.984	0.006	1.000	0.992	0.002	1.000
1.2	Max	1.260	1.140	0.180	1.225	1.180	0.070	1.214	1.194	0.030	1.210	1.198	0.018	1.210
	Min	1.200	1.080	0.060	1.200	1.155	0.020	1.200	1.184	0.006	1.200	1.192	0.002	1.200
1.6	Max	1.660	1.540	0.180	1.625	1.580	0.070	1.614	1.594	0.030	1.610	1.598	0.018	1.610
	Min	1.600	1.480	0.060	1.600	1.555	0.020	1.600	1.584	0.006	1.600	1.592	0.002	1.600
2	Max	2.060	1.940	0.180	2.025	1.980	0.070	2.014	1.994	0.030	2.010	1.998	0.018	2.010
	Min	2.000	1.880	0.060	2.000	1.955	0.020	2.000	1.984	0.006	2.000	1.992	0.002	2.000
2.5	Max	2.560	2.440	0.180	2.525	2.480	0.070	2.514	2.494	0.030	2.510	2.498	0.018	2.510
	Min	2.500	2.380	0.060	2.500	2.455	0.020	2.500	2.484	0.006	2.500	2.492	0.002	2.500
3	Max	3.060	2.940	0.180	3.025	2.980	0.070	3.014	2.994	0.050	3.010	2.998	0.018	3.010
	Min	3.000	2.880	0.060	3.000	2.955	0.020	3.000	2.984	0.006	3.000	2.992	0.002	3.000
4	Max	4.075	3.930	0.220	4.030	3.970	0.090	4.018	3.990	0.040	4.012	3.996	0.024	4.012
	Min	4.000	3.855	0.070	4.000	3.940	0.030	4.000	3.978	0.010	4.000	3.988	0.004	4.000
5	Max	5.075	4.930	0.220	5.030	4.970	0.090	5.018	4.990	0.040	5.012	4.996	0.024	5.012
	Min	5.000	4.855	0.070	5.000	4.940	0.030	5.000	4.978	0.010	5.000	4.988	0.004	5.000

Now, I will go on to kindly if you see my monitor again here; you will notice this is a very very simple, probably the simplest which I have already shown you earlier. You may wondering can we randomly give those dimensions? No.

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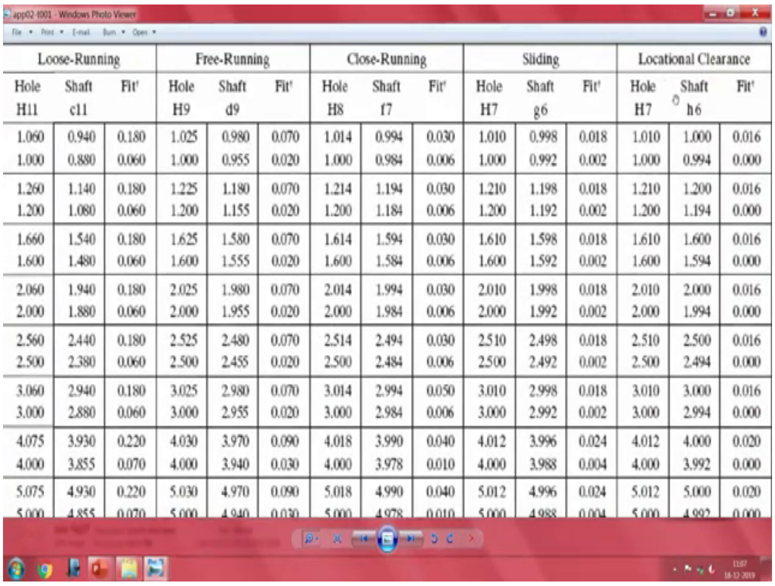

Loose-Running			Free-Running			Close-Running			Sliding			Locational Clearance		
Hole H11	Shaft c11	Fit'	Hole H9	Shaft d9	Fit'	Hole H8	Shaft f7	Fit'	Hole H7	Shaft g6	Fit'	Hole H7	Shaft h6	Fit'
1.060 1.000	0.940 0.880	0.180 0.060	1.025 1.000	0.980 0.955	0.070 0.020	1.014 1.000	0.994 0.984	0.030 0.006	1.010 1.000	0.998 0.992	0.018 0.002	1.010 1.000	1.000 0.994	0.016 0.000
1.260 1.200	1.140 1.080	0.180 0.060	1.225 1.200	1.180 1.155	0.070 0.020	1.214 1.200	1.194 1.184	0.030 0.006	1.210 1.200	1.198 1.192	0.018 0.002	1.210 1.200	1.200 1.194	0.016 0.000
1.660 1.600	1.540 1.480	0.180 0.060	1.625 1.600	1.580 1.555	0.070 0.020	1.614 1.600	1.594 1.584	0.030 0.006	1.610 1.600	1.598 1.592	0.018 0.002	1.610 1.600	1.600 1.594	0.016 0.000
2.060 2.000	1.940 1.880	0.180 0.060	2.025 2.000	1.980 1.955	0.070 0.020	2.014 2.000	1.994 1.984	0.030 0.006	2.010 2.000	1.998 1.992	0.018 0.002	2.010 2.000	2.000 1.994	0.016 0.000
2.560 2.500	2.440 2.380	0.180 0.060	2.525 2.500	2.480 2.455	0.070 0.020	2.514 2.500	2.494 2.484	0.030 0.006	2.510 2.500	2.498 2.492	0.018 0.002	2.510 2.500	2.500 2.494	0.016 0.000
3.060 3.000	2.940 2.880	0.180 0.060	3.025 3.000	2.980 2.955	0.070 0.020	3.014 3.000	2.994 2.984	0.050 0.006	3.010 3.000	2.998 2.992	0.018 0.002	3.010 3.000	3.000 2.994	0.016 0.000
4.075 4.000	3.930 3.855	0.220 0.070	4.030 4.000	3.970 3.940	0.090 0.030	4.018 4.000	3.990 3.978	0.040 0.010	4.012 4.000	3.996 3.988	0.024 0.004	4.012 4.000	4.000 3.992	0.020 0.000
5.075 5.000	4.930 4.855	0.220 0.070	5.030 5.000	4.970 4.940	0.090 0.030	5.018 5.000	4.990 4.978	0.040 0.010	5.012 5.000	4.996 4.988	0.024 0.004	5.012 5.000	5.000 4.992	0.020 0.000

Depending on the type of application, we have things like you know loose running, free running, close running, sliding, locational clearance, shaft of things; and depending on the basic size what are the variations that are allowed have been given here. You have seen this know, these tables have been standardized.

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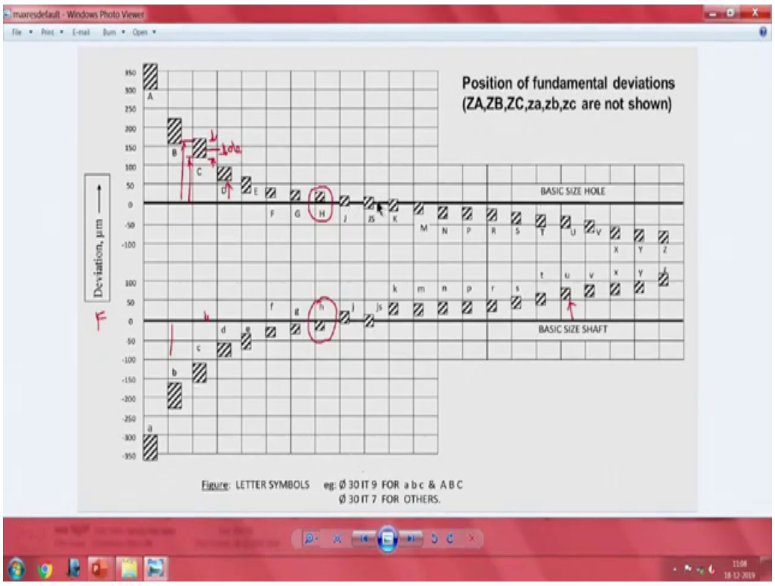

Generally, J and J S, especially J's is what is most commonly used and preferred.

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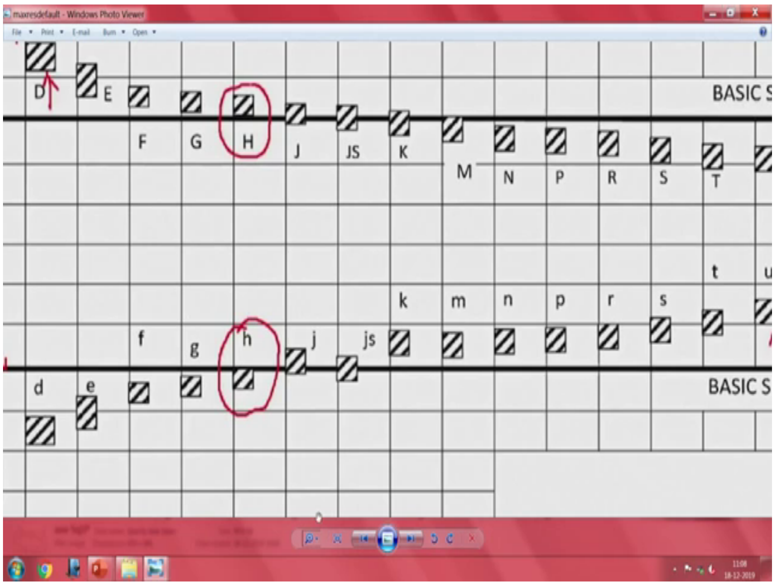

Because these are transitional saying, when you have a nominal dimension, most of our things can fall on both sides of it. In contrast when you are having whole based one sided simple tolerances H and this H are used. In the case of small h you have seen this, always the shaft is smaller than the nominal dimension and in the case the whole will always bigger than the nominal dimension.

So, and then the earlier slide show you do about what is the what do you call range of fits and so on. So, these things somebody has worked closely and found out; how to specify a particular type of fits. So, I have come back to you, all this let me go back again.

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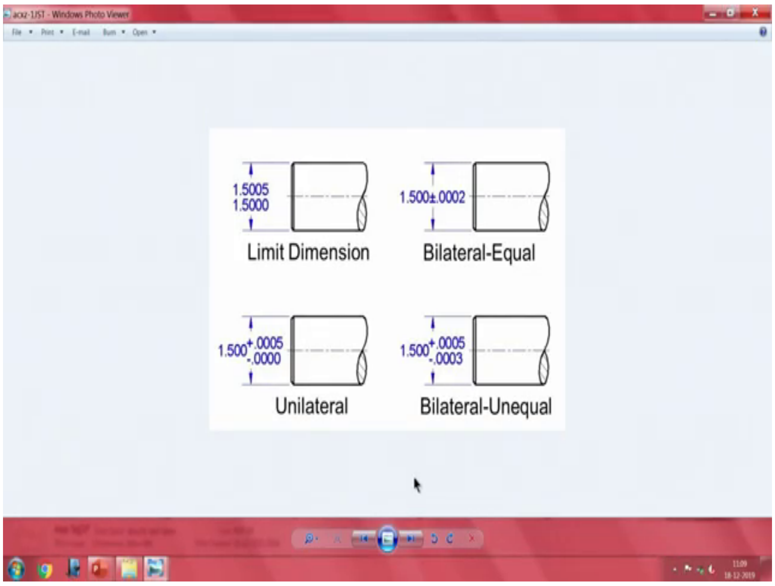

Now, we come to, if you remember the earlier thing, much earlier I have mentioned you; mentioned you saying, there is a limit in this know the shaft happens to be 005 nominal units, beyond this the lower this thing. This shows the limits with which the shaft can be accepted, a lot of it depends on the method of manufacture. And even if you start with the machining what do you call device which has; the correct settings with the wear and tear of the tools or wear and tear of or the temperature variations and all that, small variations will occur.

Usually this sort of designations are used equal deviation on both sides, 1.5 plus or minus it is actually; because it was 05 you know, must be 0025, this will follow within that there is a bilateral measured equally on both sides. This one is about unequal variation, you have seen that know; they have put 003 on one side, 005 on one side saying, it can be a little more on the positive side, little less on the negative side.

And these are typically whenever we talk about interferences and all that one side; if you remember in that get a H, small h and big H and things fall within this, these are all standard way of designing things. Now, if you take a very complex assembly, in this case this is probably a speed reducer or a you know gearbox; you will notice that there are so many elements here which rotate and this 1, 2 one assembly here, one assembly here are the bearings that need to be what do you call assembled here.

So, the next mention is about all about, let me go back here and start with; at this point I have looked around and then I will start with probably FAg both SKF and FAG are the leaders.

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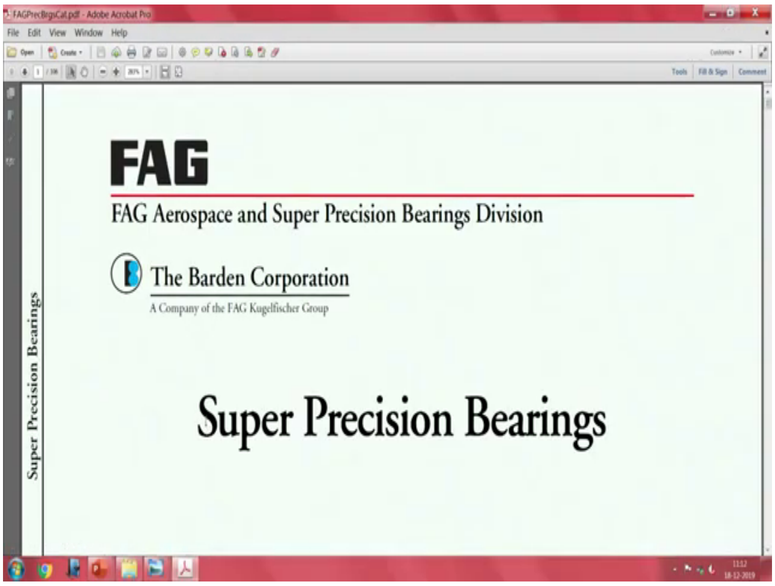

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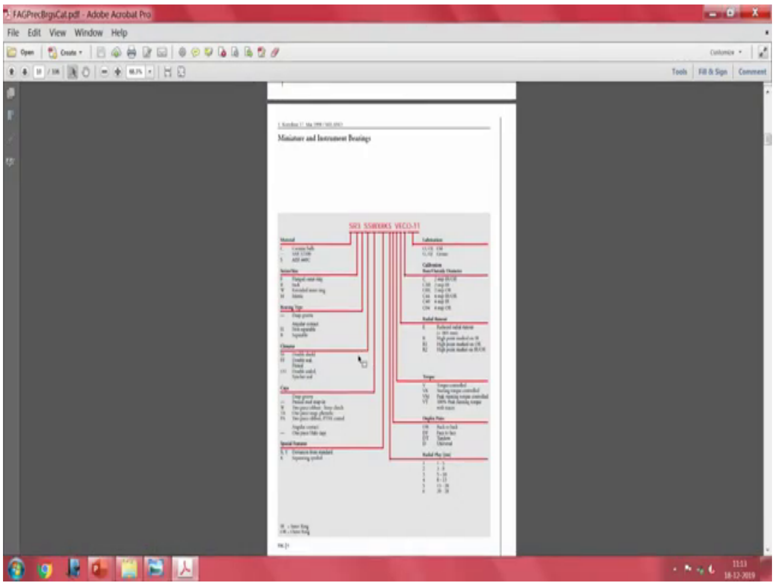

Now, these people give, one is the application; when you go down with the application one of the first thing you can talk about is, specification and at one point they give things about how, where we use this for the applications.

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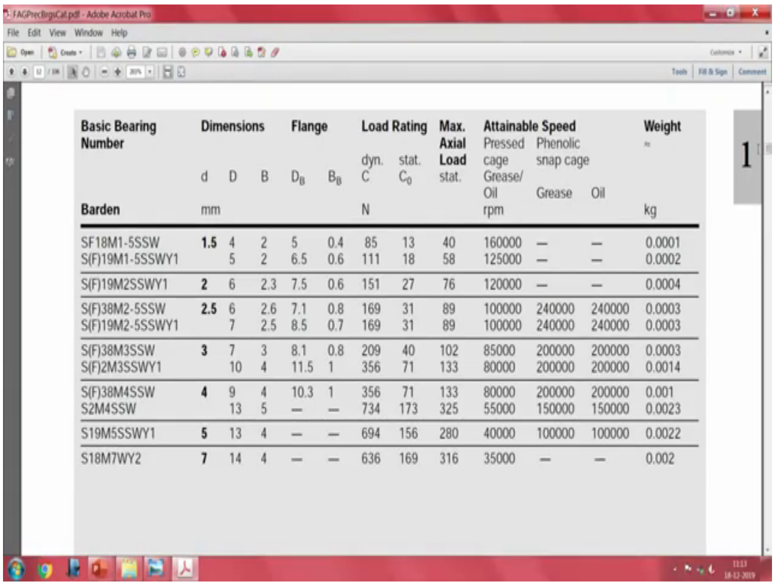

Basic Bearing Number	Dimensions			Flange		Load Rating		Max. Axial Load	Attainable Speed			Weight
						dyn.	stat.		Pressed cage	Phenolic snap cage		≈
	d	D	B	D_B	B_B	C	C_0	stat.	Grease/ Oil	Grease	Oil	
Barden	mm					N			rpm			kg
SF18M1-5SSW	**1.5**	4	2	5	0.4	85	13	40	160000	—	—	0.0001
S(F)19M1-5SSWY1		5	2	6.5	0.6	111	18	58	125000	—	—	0.0002
S(F)19M2SSWY1	**2**	6	2.3	7.5	0.6	151	27	76	120000	—	—	0.0004
S(F)38M2-5SSW	**2.5**	6	2.6	7.1	0.8	169	31	89	100000	240000	240000	0.0003
S(F)19M2-5SSWY1		7	2.5	8.5	0.7	169	31	89	100000	240000	240000	0.0003
S(F)38M3SSW	**3**	7	3	8.1	0.8	209	40	102	85000	200000	200000	0.0003
S(F)2M3SSWY1		10	4	11.5	1	356	71	133	80000	200000	200000	0.0014
S(F)38M4SSW	**4**	9	4	10.3	1	356	71	133	80000	200000	200000	0.001
S2M4SSW		13	5	—	—	734	173	325	55000	150000	150000	0.0023
S19M5SSWY1	**5**	13	4	—	—	694	156	280	40000	100000	100000	0.0022
S18M7WY2	**7**	14	4	—	—	636	169	316	35000	—	—	0.002

So, various things about what is the basic dimensions and the load rating dynamic and static grounded and then maximum axial load and all these things attainable speed. The type of you know lubrication you use and so on, all of these the manufacturers give; usually the manufacturers mention all these things.

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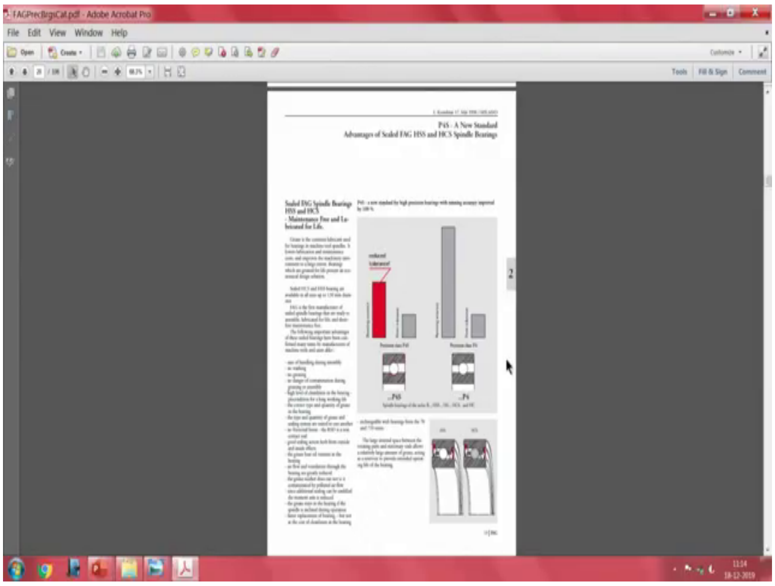

If you go down further, the application manuals fully give details of what is the type of the tolerances which they give the application of heat. And for high precision bearings what is the tolerance within the form of, what is the what you call, how you specify various things here are all mentioned here.

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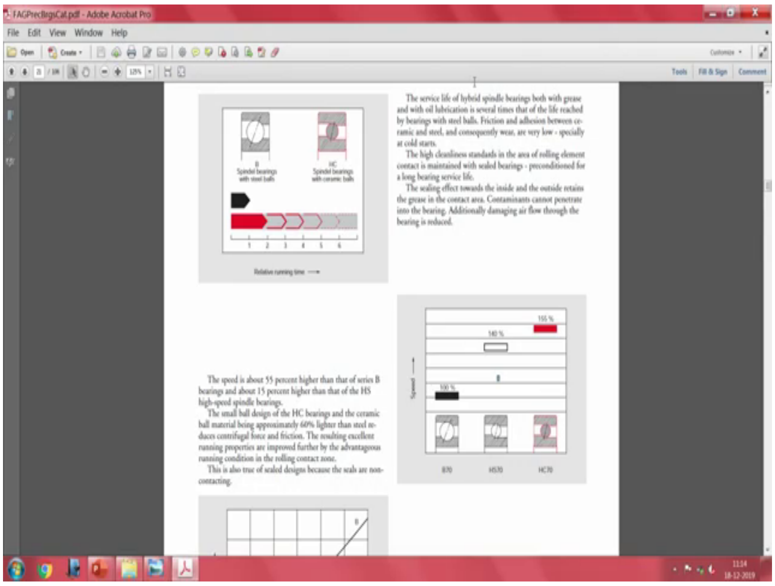

You have seen here, saying with respect to speed where exactly this application can be used and which is the type of bearing we try to use. And the service factor saying bearings with steel balls, what is the service factor and all that.

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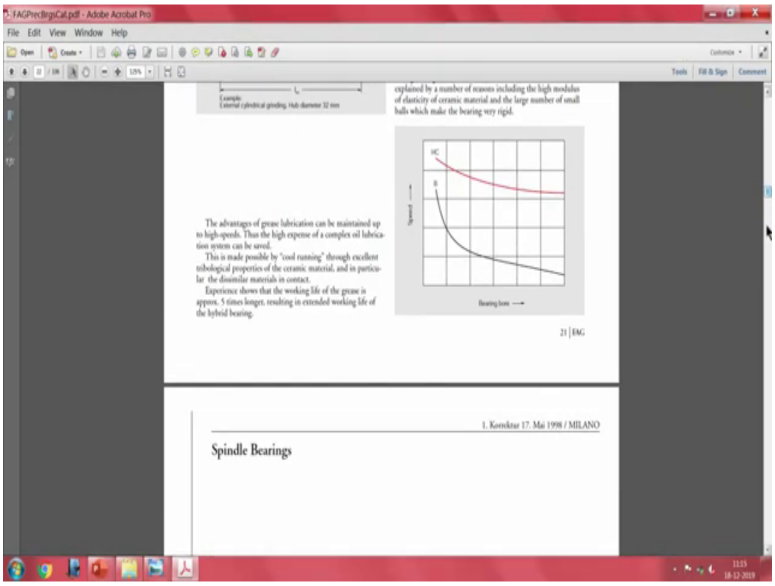

They have worked a lot and decided on how to maintain these various factors.

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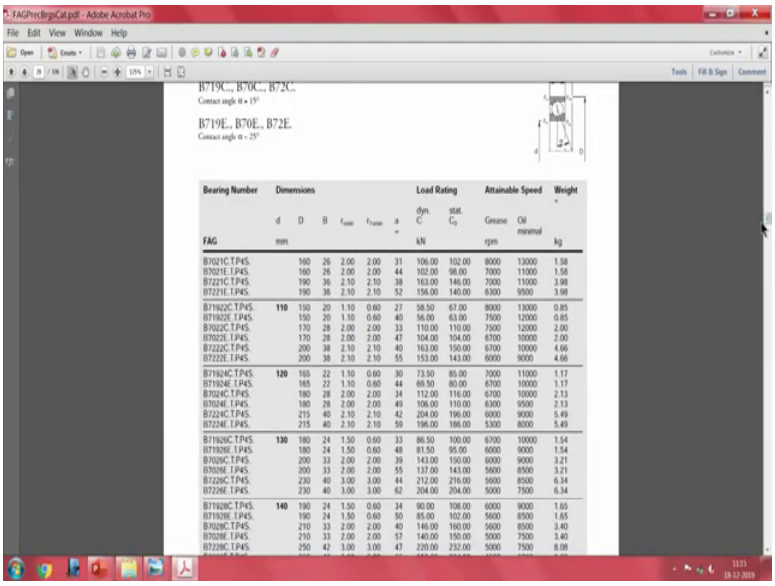

B719C.., B70C.., B72C..
Contact angle α = 15°

B719E.., B70E.., B72E.
Contact angle α = 25°

Bearing Number	Dimensions						Load Rating		Attainable Speed		Weight
	d	D	B	r_{smin}	r_{1smin}	a ≈	dyn. C	stat. C_0	Grease	Oil minimal	≈
FAG	mm						kN		rpm		kg
B7021C.T.P4S.		160	26	2.00	2.00	31	106.00	102.00	8000	13000	1.58
B7021E.T.P4S.		160	26	2.00	2.00	44	102.00	98.00	7000	11000	1.58
B7221C.T.P4S.		190	36	2.10	2.10	38	163.00	146.00	7000	11000	3.98
B7221E.T.P4S.		190	36	2.10	2.10	52	156.00	140.00	6300	9500	3.98
B71922C.T.P4S.	**110**	150	20	1.10	0.60	27	58.50	67.00	8000	13000	0.85
B71922E.T.P4S.		150	20	1.10	0.60	40	56.00	63.00	7500	12000	0.85
B7022C.T.P4S.		170	28	2.00	2.00	33	110.00	110.00	7500	12000	2.00
B7022E.T.P4S.		170	28	2.00	2.00	47	104.00	104.00	6700	10000	2.00
B7222C.T.P4S.		200	38	2.10	2.10	40	163.00	150.00	6700	10000	4.66
B7222E.T.P4S.		200	38	2.10	2.10	55	153.00	143.00	6000	9000	4.66
B71924C.T.P4S.	**120**	165	22	1.10	0.60	30	73.50	85.00	7000	11000	1.17
B71924E.T.P4S.		165	22	1.10	0.60	44	69.50	80.00	6700	10000	1.17
B7024C.T.P4S.		180	28	2.00	2.00	34	112.00	116.00	6700	10000	2.13
B7024E.T.P4S.		180	28	2.00	2.00	49	106.00	110.00	6300	9500	2.13
B7224C.T.P4S.		215	40	2.10	2.10	42	204.00	196.00	6000	9000	5.49
B7224E.T.P4S.		215	40	2.10	2.10	59	196.00	186.00	5300	8000	5.49
B71926C.T.P4S.	**130**	180	24	1.50	0.60	33	86.50	100.00	6700	10000	1.54
B71926E.T.P4S.		180	24	1.50	0.60	48	81.50	95.00	6000	9000	1.54
B7026C.T.P4S.		200	33	2.00	2.00	39	143.00	150.00	6000	9000	3.21
B7026E.T.P4S.		200	33	2.00	2.00	55	137.00	143.00	5600	8500	3.21
B7226C.T.P4S.		230	40	3.00	3.00	44	212.00	216.00	5600	8500	6.34
B7226E.T.P4S.		230	40	3.00	3.00	62	204.00	204.00	5000	7500	6.34
B71928C.T.P4S.	**140**	190	24	1.50	0.60	34	90.00	108.00	6000	9000	1.65
B71928E.T.P4S.		190	24	1.50	0.60	50	85.00	102.00	5600	8500	1.65
B7028C.T.P4S.		210	33	2.00	2.00	40	146.00	160.00	5600	8500	3.40
B7028E.T.P4S.		210	33	2.00	2.00	57	140.00	150.00	5000	7500	3.40
B7228C.T.P4S.		250	42	3.00	3.00	47	220.00	232.00	5000	7500	8.08

This is one of the random catalogs I have picked up; installation and maintenance guide saying, how does one actually.

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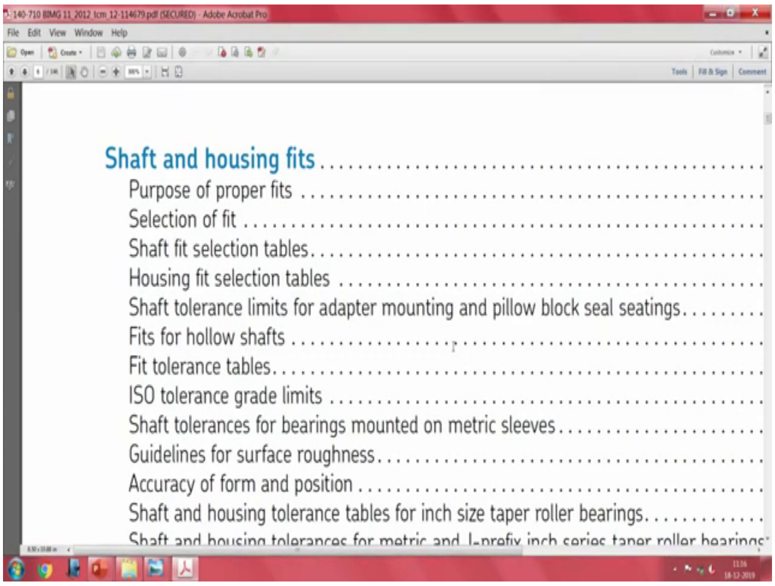

You have seen this, here the errors talked about shaft and housing fits saying; it is very very important for us to determine selection tables, housing fit, shaft fit, fits for hallow shafts, ISO tolerance grade limits and so on.

So, every bearing engineering manual gives all these things here; why I am mentioning it is, you can just look around and how close and how the manufacturing follow certain standards. And if you leave, let us say you do not get any one of the original bearings or you have opened a old housing or you want to make alternate sources, each of these manufacturers also give.

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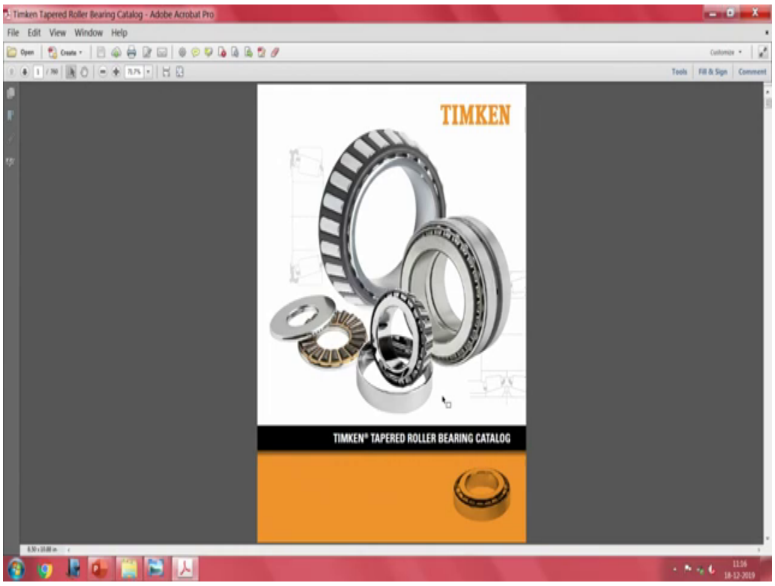

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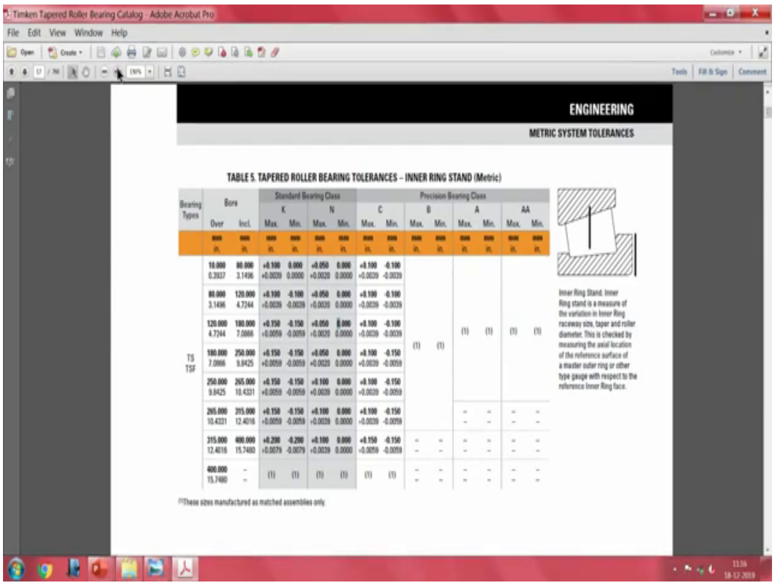

ENGINEERING

METRIC SYSTEM TOLERANCES

TABLE 5. TAPERED ROLLER BEARING TOLERANCES – INNER RING STAND (Metric)

Bearing Types	Bore		Standard Bearing Class				Precision Bearing Class							
			K		N		C		B		A		AA	
	Over	Incl.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.
TS TSF	10.000 0.3937	80.000 3.1496	+0.100 +0.0039	0.000 0.0000	+0.050 +0.0020	0.000 0.0000	+0.100 +0.0039	-0.100 -0.0039						
	80.000 3.1496	120.000 4.7244	+0.100 +0.0039	-0.100 -0.0039	+0.050 +0.0020	0.000 0.0000	+0.100 +0.0039	-0.100 -0.0039						
	120.000 4.7244	180.000 7.0866	+0.150 +0.0059	-0.150 -0.0059	+0.050 +0.0020	0.000 0.0000	+0.100 +0.0039	-0.100 -0.0039			(1)	(1)	(1)	(1)
	180.000 7.0866	250.000 9.8425	+0.150 +0.0059	-0.150 -0.0059	+0.050 +0.0020	0.000 0.0000	+0.100 +0.0039	-0.150 -0.0059	(1)	(1)				
	250.000 9.8425	265.000 10.4331	+0.150 +0.0059	-0.150 -0.0059	+0.100 +0.0039	0.000 0.0000	+0.100 +0.0039	-0.150 -0.0059						
	265.000 10.4331	315.000 12.4016	+0.150 +0.0059	-0.150 -0.0059	+0.100 +0.0039	0.000 0.0000	+0.100 +0.0039	-0.150 -0.0059			– –	– –	– –	– –
	315.000 12.4016	400.000 15.7480	+0.200 +0.0079	-0.200 -0.0079	+0.100 +0.0039	0.000 0.0000	+0.150 +0.0059	-0.150 -0.0059	– –	– –	– –	– –	– –	– –
	400.000 15.7480	– –	(1)	(1)	(1)	(1)	(1)	(1)	– –	– –	– –	– –	– –	– –

(1)These sizes manufactured as matched assemblies only.

Inner Ring Stand. Inner Ring stand is a measure of the variation in Inner Ring raceway size, taper and roller diameter. This is checked by measuring the axial location of the reference surface of a master outer ring or other type gauge with respect to the reference Inner Ring face.

You have seen this, the best four of them which I have managed to get, there are standards meant for even roller bearings. Now, understanding and going through these engineering manuals, it is easy for you to carry out your design. Just for you know just to tell you and then that I could actually locate it.

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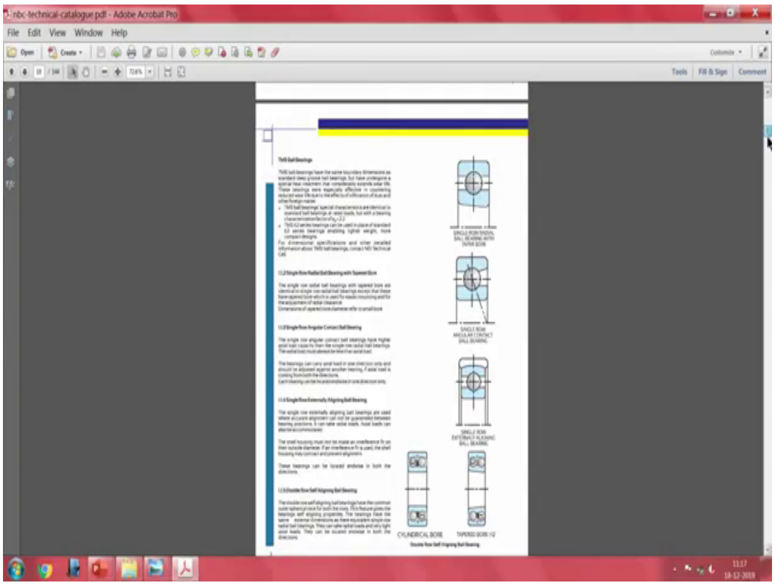

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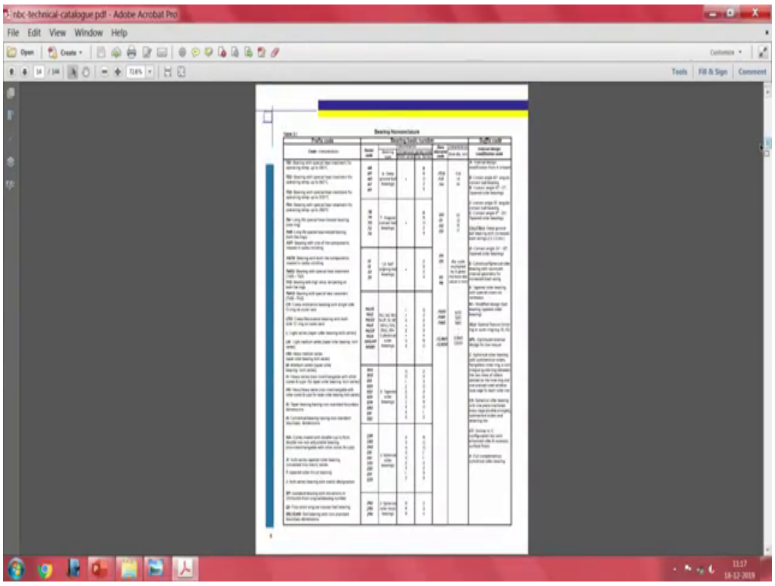

If you go through any of these catalogs, you get full details of how best you can select a particular type of a bearing and you can interchange it; while this looks very obvious and unnecessarily repetitive. Unfortunately for sheet metal it looks like, they are not that commonly available.

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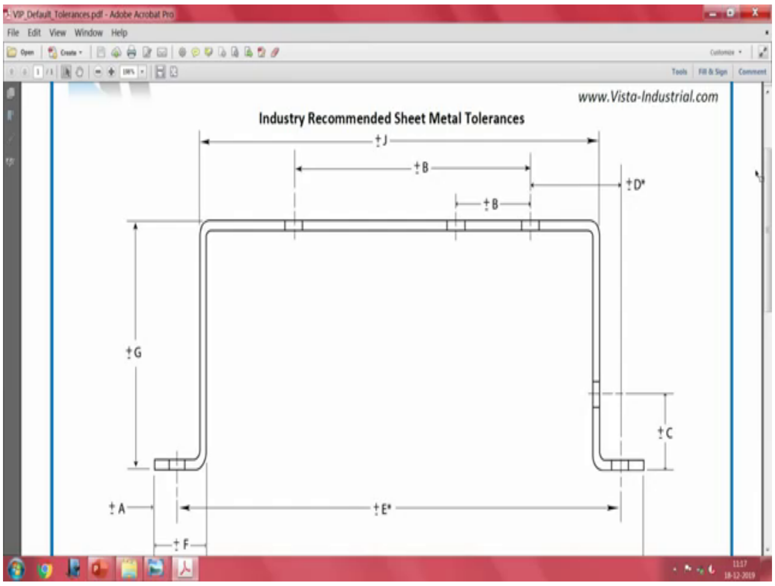

However, regular professional manufacturers have standard ion on these things also. So, one should be careful, especially after making your simple design whether things which are part of these various standards are followed and you are able to utilize existing knowledge and try to make that things fit each other.

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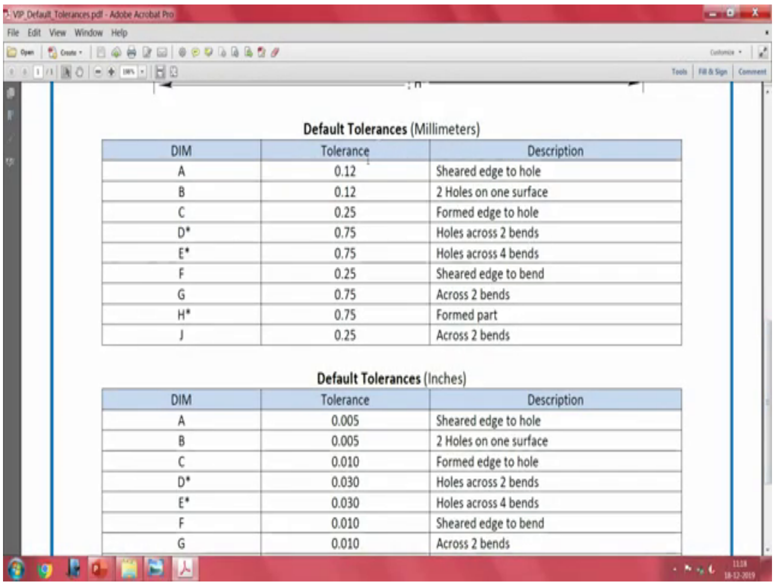

Default Tolerances (Millimeters)

DIM	Tolerance	Description
A	0.12	Sheared edge to hole
B	0.12	2 Holes on one surface
C	0.25	Formed edge to hole
D*	0.75	Holes across 2 bends
E*	0.75	Holes across 4 bends
F	0.25	Sheared edge to bend
G	0.75	Across 2 bends
H*	0.75	Formed part
J	0.25	Across 2 bends

Default Tolerances (Inches)

DIM	Tolerance	Description
A	0.005	Sheared edge to hole
B	0.005	2 Holes on one surface
C	0.010	Formed edge to hole
D*	0.030	Holes across 2 bends
E*	0.030	Holes across 4 bends
F	0.010	Sheared edge to bend
G	0.010	Across 2 bends

So, if you look back to the this big table default tolerances and millimeters, see what all has been specified here; across 2 bends, across formed part, across holes across 2 bends, holes across 4 bends, formed edge to hole all these have been somewhat regulated and this is a and whenever a tolerance like this has mentioned, it is almost like a legal or binding document on the supplier.

So, you need to consider all this. Look it up, look up against the available what you call open documentation and tried to adopt one of these things. When you adopt it, chances of your failure or surprise in what you call fabrication will full be, you can huge amount of.

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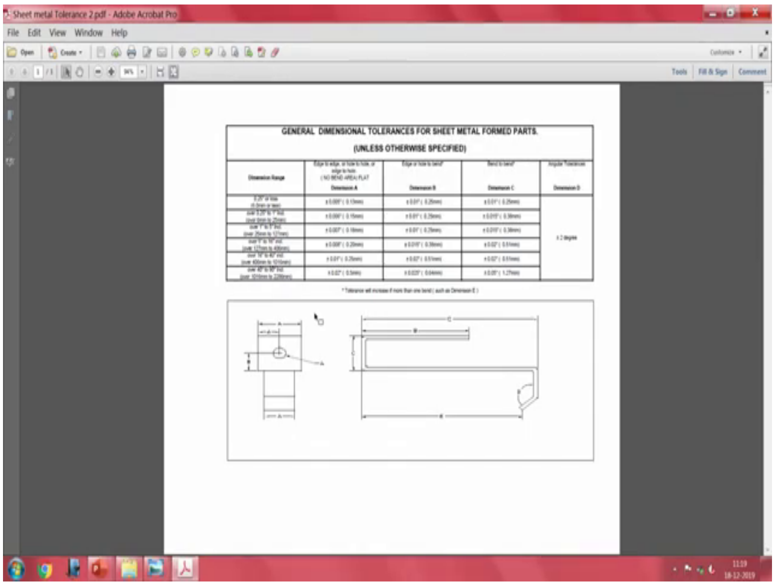

This I had shown you earlier. So here things like general tolerances for sheet metal formed parts, these are all mentioned. So, it is convenient and almost mandatory for you to follow one of these which other industry people follow it. And then if you follow it chances of you are going wrong will be negligible and you will not end up with this funny design which I have made.

While at one level this design looks nice, another level the fabrication issues I have not been taken care of. So, the whole I will take a break of this is a whole session here at this point, so that you will try to see how well variations on production also have to be incorporated into your designs. While solid modeling is convenient, I can make a very impressive looking thing. One way of dealing with it is, probably make two of these parts; one within outside of the tolerance, adjust out the extreme at one tolerance, another is the lower into the tolerance and see whether they will fit each other by manually trying to show them on your screen.

That will only clarify your concepts in for you and the new software as I have told you, there are so many of these the solid modeling software have this incorporated already. So, you can check between part a and part b under what conditions, what type of a fit results in this. So, if I get a chance and if I get an access to one of those things; I will try to show it to you in maybe there are next lecture; saying in case you have a regular full-fledged solid modeling software, how these tolerances and how this fits are taken care of.

So, thank you, I will continue in the next this thing.

Thank you.