**Lighter Than Air Systems**
**Prof. Rajkumar S. Pant**
**Department of Aerospace Engineering**
**Indian Institute of Technology - Bombay**

**Lecture - 26**
**Static Lift Prediction Part II**

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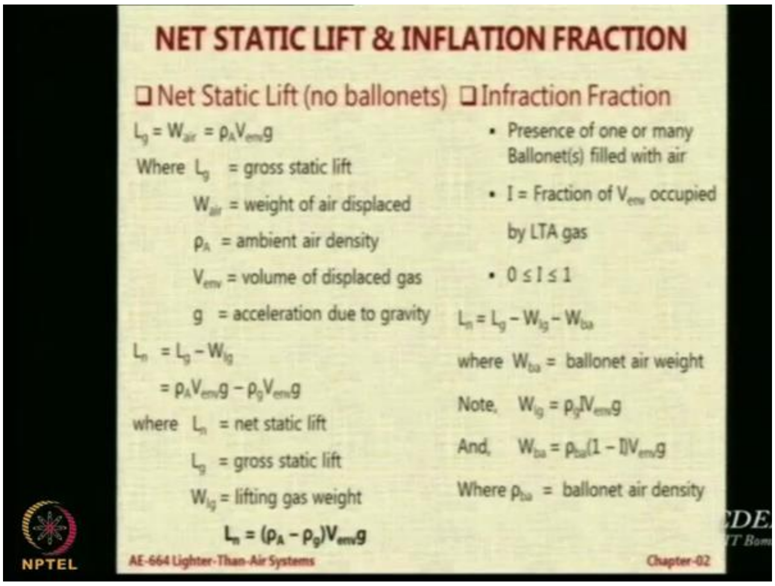


Now we have discussed the concept of ballonets is but at the moment let us assume there are no ballonets which means you have a simple envelope it has got nothing inside. So the volume occupied by the gas is equal to the volume of the envelope. In this case the gross lift will be basically weight of the air which is $\rho_A$ density of the air into $V_{env}$ now, I will use this symbol $V_{env}$ thorough out for envelope volume.

And $g$ will be the acceleration gravity. So what will be the units of $L_g$ in SI system it will be Newtons. Now this is one mistake which many student will make, So it is important for me to caution you right now. By a simple check of units where $\rho$ is kg per metre cube, V is meter cube and $g$ is metre per second square you will find that it is going to come in Newtons. So, be very careful I keep warning people but people committing this mistake because they are in a hurry.

They do not look at the units and that at every point in this calculations units have to be confirmed. So, for the force $L_g = \rho_A V_{env} g$ this is the gross static left. And the net static lift will be the gross static lift minus the weight of the lifting gas. It is straight forward, therefore the weight of the lifting gas can be assumed to be $\rho_g V_{env} g$. So the difference between them.

So then we come up with the simplest formula the most basic formula which you will use throughout your calculations and that use the net lift which is available from any LTA system is the difference in the density between the ambient air and the gas volume times envelope volume into $g$ assuming that the entire envelope space is occupied by the lifting gas. But this is never the case except under one condition.

So which is the operating condition at which this formula is perfectly applicable? So for a typical airship what is the operating condition at which this formula is correctly applicable? At the ceiling. Now the altitude at which this thing happens between the altitude at which the LTA gas occupies the entire volume that altitude when the ballonets are completely flush that happens at the ceiling and this altitude is called as the pressure height. This is important term which you can note down. Pressure height is the altitude at which the ballonets are flushed, if present and the complete volume occupied by the lifting gas is there in the full envelope.

And also the full envelope is occupied by the lifting gas that there is no ballonets. Above this altitude is not very easy to go you have to resort to dumping of the gas or some other measures. Now we know that typical airship has ballonets we have seen last time why we give ballonets. Do you remember what is the purpose of ballonets? To control the buoyancy to control its equilibrium and is that the only reason?

For pitch control and any other reason? Angle of attack is pitch only giving the angle of attack means allowing it to pitch. One more important purpose is to relieve the stresses on the envelope. So, from structural consideration if you do not provide bollonets and if you take it to a very high altitude then the $\Delta P$ between inside and outside, outside pressure will keep falling inside will remain same.

Therefore there will be a huge amount of tear. So by using ballonets you are giving lesser or more volume for the same LTA gas and thus you relieve the pressure. So pressure control, buoyancy control and trim these are the 3 reasons why we have one or many ballonets. So now if you have a situation which is most typical situation for a manned airship at least is that you like one of many ballonet is filled with air.

So we define a term called as Infraction fraction. ok it is a veryy funny name Infraction Fraction and that is fraction of the envelope occupied by the LTA gas. So (1 – I) will be fraction of the gas occupied by the ballonets. So, the value of I infraction fraction will be 0 to 1. It will be 1 if there are no ballonets or if you are at a pressure height it may be 0.8, 0.7 typically the ballonets volume tends to be around 20 - 25% of the envelope volume, but this is not a fixed number.

This number has to be calculated by you based on how much $\Delta H$ you would like to provide from which height you will operate and up to what height you will go? These important parameters determined amount of ballonet volume that you need to provide. So if there is air in the gas bag then the net lift will not be equal to gross lift minus the lifting gas weight.

There will be one more term to be subtracted which is the weight of the air in the ballonets is called the $W_{ba}$. And $W_{ba}$ will be volume of the ballonet at that particular condition times the density of air which will be seen as density of air at outside. Because a ballonet is always into contact with the ambient air it take air from outside. However from various altitudes when it takes in air it will have different density compared to said sea level. So note that $W_{lg}$ that is the weight of the lifting gas.

And now all these items you are not suppose to see on the board and nod your head you are supposed to note down because very soon you will be deriving expressions to use it. So, it is not a good idea to just watch it, it is good idea to I see some students are doing it, is note down these expressions because the equation will become very very complicated after a few slide. So wherever the lifting gas will be density of the gas into I into $V_{env}$ where I is the Infraction fraction times $g$.

And weight of the air in the ballonet will be $W_{ba} = \rho_{ba}(1 - I)V_{env}g$. the pressure inside the ballonets is very slightly more than outside. To maintain its shape so you can assume it to be roughly same as outside because there is a direct communication through a fan or through a injector. Because those walls are freely opening wall so the pressure is communicated. The ballonet is normally in touch with atmosphere.

So the pressure inside the bollonet will be roughly the same as outside. Unless you close the whole system and then you push pump air inside then the pressure will change. So, the simple formula of net lift with the presence of ballonet it just get slightly modified with this Infraction Fraction I.

So, with this we can calculate the net so if someone tells you that an airship has 20% ballonet and the volume is 1000 metre cube and operating at some at some altitude with Helium. So you know $\rho_g$ at an altitude, you know $\rho_A$ at the altitude infraction fraction is given. You can easily calculate the net lift that will be available. And this net lift is meant for you to utilise. So the payload will be this net lift minus the self weight.

So net lift is what vertical force this whole system is going to give you. You can use that force to carry payload but you will have some weight of the Gondola, fins and other things. So, that will be the dead weight to the payload available or fuel plus a useful load will be net lift minus system weight. And you can tradeoff that between fuel and payload. And remember you also have to also carry some ballast.

So ballast as I said removable blast, fixed ballast, jettinsonable ballast all of them are going to be part of the empty weight. So what weight you can you can throw some of which you can temporarily adjust some of which will remain fixed for centre of gravity control, but they will all be part of the empty weight you have to carry that much.