Case 1 – Weight only and no pressure thrust

Majority of load of vertical discharge should be taken by 1st hanger support. The 1st hanger support will also take load from about half of horizontal downstream run to 2nd hanger support. I estimate there would be about 3600# on 1st hanger support, and about 900 # on pump nozzle. This is based on the vertical discharge being about 20 feet total length and a total of 3650# and the run between the first and 2nd hanger being about 8 feet long and weight of 1820#.

Case 2 – Weight plus thermal expansion and no pressure thrust

Vertical run expands about 0.2" thermally in pipe and hose based on about 6 x 10^{-6} coefficient of thermal expansion at 20 ft length overall at 133 F delta T. This causes the pipe to lift off 1st hanger and would be fixed at this lift off if the hose was rigid. Due to the flexibility of the hose of about 40000 lb/in. the hose will be compressed by the same thermal deflection if the end result is that the 1st support does not lift off anymore. Therefore the compression of the hose will need to be equal to the thermal expansion to make the pipe reseat on 1st hanger. This would be a compression of 0.2". This would produce a force of about 8000# on the nozzle based on the stiffness coefficient.

However the total weight of the piping between the pump nozzle and the 2nd hanger is estimated to be about 5470# therefore if this entire load was felt by the hose it would compress about 0.14". This leaves only about 0.06" of lift at the 1st hanger.

This assumes all the thermal expansion is taken in the vertical direction by the compression of the hose. However there are other movements at the first elbow due to thermal expansion of the horizontal run that could be taking up some of the thermal expansion of the vertical discharge. If the elbow rotates clockwise then this will take up some of the thermal expansion without loading the hose in compression. This will occur since when there is lift off of 1st hanger there is now a clockwise rotation moment on the 1st elbow due to the weight of the horizontal run to the right. Also if the thermal expansion of the horizontal run causes the vertical discharge to shift to the left then this reduces the effective vertical deflection into a horizontal direction. This will occur since most of the thermal expansion of the horizontal run will be pushed into the direction of the expansion joint since it is the direction of least resistance. Say the sum of rotation and shifting of the upper elbow takes up half of the thermal expansion of the vertical run, then the remaining thermal expansion taken by the hose is 0.1"at the point where the 1st hanger just reseats, and this would put a load of compression of about 4000# on the pump nozzle. But then with all the 3D movements taking place then the some if this 4000# load would be taken by the 1st hanger if it reseats and takes some of the load. This makes sense as it may result in the 2500# load you say you are getting at the pump nozzle for the thermal case without pressure thrust.

Case 3 – Weight plus thermal plus pressure thrust

Applying a pressure thrust of about 9900# based on 60 psi at 165 Sq.in. area would put an upward force on the vertical discharge at the elbow. If the net force prior to the application on the pump nozzle was about 2500 pounds (down) then the resulting force on the nozzle would now be about 7400# upward. But your results show 7241# downward (negative), which is about the expected force but in the opposite direction. However the net deflection changes to upward of about 0.068” per your attached results, considering prior to application of the thrust force I understand that there was no lift off of the 1st hanger. Something don’t make sense here. Are you sure that the results you posted are showing the net force of the pipe on the anchor A00 pump nozzle which should be positive (up) - or are the results showing the net force of the anchor on the pipe which appears to be negative (down)? I think the net force is up on the anchor and what is shown is the force of the anchor on the pipe. I am used to using Caesar so I am not sure of all of the conventions of Autopipe.

Also, in Caesar you can print out a forces and moments report that you can see the free body forces and moments at every node in the piping so that you can follow where the forces and moments begin and end so you know how they develop and how to handle them. I would have to look at a forces and moments report to see exactly what is going on in the calculation that is resulting in the loads shown at the restraints.

That being said, I have looked at information on the hose on the manufacturer website. The hose is very much reinforced and can take longitudinal stress due to pressure and elongates just like pipe (so it doesn’t need tie rods), although maybe a little more for a given internal pressure. However I believe that it is considered to be able to transfer thrust loads. I would try to get more information from the manufacturer as to the true spring constants of the hose. Furthermore I do not believe the hose is designed to take thermal expansion by compressing axially. I believe that if it is compressed too much it will be damaged due to permanent deformation of the internal reinforcement and is not designed for axial compressive flexure other that that would normally occur under compressive stress in the general piping system. I believe it could take up axial motion of the pipe if the hose was offset so that it deflects laterally with an axial defection of the piping. So I would not count on the hose to take up too much axial deflection of say ¼” or more unless it was put in an offset position. So I would check with the manufacture again on the application and maximum allowable movements before the hose is damaged.

I am thinking that a vertical support on the discharge pipe will be required just a couple of feet above the hose. This will prevent any overloading of the hose and the pump nozzle. The drop to the pump is very large for what appears to be a 16” basalt line pipe to just hang there from the 1st hanger without any other vertical support except at the pump nozzle. A support at this location will also make construction easier I believe as it will form a support point when the system is not in operation during construction. If there is truly a resulting upward force with pressure thrust resulting in a stretching of the hose I don’t think this elongation of the hose will damage the hose since the hose is rated for an internal pressure and under the elongation during a pressure test under this rated pressure. If the hose can really transfer longitudinal pressure thrust similar to pipe then this upward thrust will just balance with the pressure thrust acting in the opposite direction on the pump. So in the end on the pump nozzle you will have a 9900# pressure thrust acting upward, 9900# pressure thrust acting downward, and 2500# force that you calculated downward with thermal loads. So net force down is 2500# considering the hose transfers longitudinal pressure loads, it is just that it hose stretches a little more than equivalent section of pipe causing the pipe to lift off the 1st hanger but the thrust loads on the pump nozzle are still balanced.

I am thinking though that the hose cannot take much compression without being damaged. So a vertical rest support would be sufficient to prevent the hose from over compressing and thereby transferring this load to the pump nozzle if the net force is really down instead of up with say when the system is shut down or when the internal pressure is below 60 psi MWP. If you are using the 60 psi as the MAWP but the actual operating pressure is much lower than the net force may be down so the pipe will not lift off this lower support.   So this lower support will serve to take any vertical load down when the 1st hanger support lifts off.