1. Nozzle Retaining Ring
   1. Must have at least ½” wall thickness
   2. Forward end must have space for a ¼” or thicker o-ring on the outer diameter
      1. O-ring groove requirements
         1. Groove height must be <80% of thickness of ring to ensure compression
         2. Groove OD cannot allow for less than 50% of retainer to come into contact with nozzle
         3. Groove must give adequate compression to hold o-ring on with a small amount of stretch
            1. Reference McMaster Carr website for “actual” dimensions of o-rings
      2. Purpose is for sealing the motor’s aft end
      3. Thicker o-rings for larger motors is not a requirement, but margins become tight
   3. Must be long enough to contain pins at least 2x pin diameter from top or bottom
      1. Makes sure that there is no failure in the retainer due to yielding
      2. Drilling is not perfectly accurate, and leeway must be given for drill to work properly
2. Nozzle Basic Requirements
   1. Phenolic must be glued on top of the graphite section to ensure that there are no joints parallel to flow direction
   2. Graphite and phenolic inserts must be in compression during firing by use of steps
      1. Step thickness must be ~10% of motor diameter
   3. A 1” length of phenolic must mate with the ID of the casting tube
      1. Ensures that no heated gas flows to the aluminum
      2. Additionally allows for pressure to reach cavity between aluminum and phenolic
         1. If a single flow path is not generated then the phenolic must take the pressure, and will crack, leading to failure
   4. Sections must be mated using a high temperature epoxy (IE JB-weld), and will have final profile machined as a single piece
   5. Nozzle internal profile does not need to be exact, but no sharp angles can be created in flow path Part Specific Nozzle Requirements
3. Specific Requirements
   1. Graphite Requirements
      1. Minimum thickness must be greater than 10% of motor diameter
      2. Minimum thickness at throat must be greater than 25% motor thickness, or 6”, whichever is smaller
         1. Only allowance is if the throat is greater than 4”, then a 2” thickness is required
      3. Section must be long enough that 15o diverging half angle is reached 1” before bottom of nozzle
      4. Section must be long enough so that aft end is 166% ID of the throat
      5. OD must be roughed for gluing into phenolic
   2. Phenolic requirements
      1. 1.5” sections must be