Directional drilling allows for companies to extract oil and gas from tricky formations. Generally in directional drilling a vertical bore begins to turn at a constant radius until the desired direction is acquired. During drilling the drill shaft is subjected to a torsional force, a compressive normal force, and an internal pressure as drilling fluid is pumped to the drill head. In this problem we will assume that we are drilling with a 8 inch outer diameter drill shaft with 0.5" thick walls. The torsional force applied to the shaft is 1000 Kip ft. The normal compressive force is 8,000 lbs. The internal pressure is 800 psi, and the radius of curvature in the bend of the pipe is 1,500 ft. The drill shaft is made of steel with a modulus of elasticity of 30,000 Ksi and a Poisson's ratio of 0.3.

Please:

A1) Determine the stresses in the longitudinal and hoop directions of the pipe accounting for the normal force, pressure and the radius of curvature of the bend in the shaft.

A2) Generate a stress element that indicates the stresses along the longitudinal and hoop directions complete with the torsional shear stress.

B) Construct Mohr's circle for the stress element calculated in part A. and determine the principle stresses and maximum in plane shear stress.

C) Considering max principle stress only, what is the factor of safety on this design assuming a yield stress of 40 Ksi.

D) Considering max in plane shear stress, what is the factor of safety assuming a shear yield stress of 11.5 Ksi.?