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PVC Pipe Design Stress

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1. Introduction

A decision needs to be made in the next few months regarding the feasibility of constructing the TASD Detector. Because of the short time period on which to make a decision detailed testing of PVC and extrusions will no be completed. However, critical calculations can occur but these require the establishment of an effective stress that is the maximum stress within the PVC extrusions which will insure that failure will not occur due to static load or long term creep effects. In order to determine an effective stress value that can be used in near term calculations the PVC pipe industry has been examined because of its extensive testing and experience with PVC materials.

2. PVC Classification

The basic materials for PVC pipe is made out of PVC 12454-B, 12454-C or 14333-D as defined in ASTM D1784 "Standard Specification for Rigid PVC Compounds". The yield stress of these compounds is in excess of 6,000psi. This ASTM standard establishes a classification system based on required material properties but not composition. The classification system defines base resin, impact resistance, tensile strength, modulus of elasticity, deflection temperature under load and flammability. The actual composition of the PVC is not defined.

3. PVC Pipe Classifications

The Plastics Pipe Institute has designated a classification system that is based on a design stress for the material. The design stress is determined by the hoop stress that when applied continuously, will cause failure of the pipe at 1000,000 hours (11.43 years). This failure stress is determined by conducting ASTM D2837 test for long term creep. This hoop stress then defines an effective stress that is used to calculate the stress in the pipe.

There are several classifications of material used in pipe. The most commonly used class is designated as PVC2110 which has a design stress of 1,000psi. Other classifications and design stresses are:

Designation	Design Stress
PVC1120	2000psi
PVC1220	2000psi
PVC2120	2000psi
PVC2116	1600psi
PVC2112	1250psi
PVC2110	1000psi

There is not a single formulation for each grade of PVC pipe. Performance of the product is established by testing and compliance to the ASTM standards. Manufacturers typically consider the formulation of their products propriety.

Discussions with the engineers at the Plastic Pipe Institute and The Uni-Bell PVC Pipe Associations revealed that there is no specific formulation of the material for each designation, unlike steel. The materials with a design stress of 2,000psi typically contain no more than 5-7% calcium carbonate. The materials with lower design strengths have more calcium carbonate but the exact amounts are proprietary.

4. PVC Pressure ratings

PVC pipe is classified by pressure ratings. ASTM Standard D1785 "Standard Specification for PVC Pipe, Schedule 40, 80 and 120" defines the geometry and maximum allowable pressure in various size pipes and classification of pipe.

The very simple formula for relating hoop stress to applied pressure is used in this calculation.

$(D-2*t)*P=S*2*t$

Where D is the outer diameter of the pipe, P is the internal pressure, t is the wall thickness, and S is the limiting effective stress used.

The pressure ratings on the pipe are determined from these design stresses.

5. Conclusion

The PVC pipe industry defines effective stresses based on the creep life of the material. This is a similar criterion that should be used for NOVA. However, while it is possible to obtain PVC extrusions which have very high yield strengths (6,000-7,000psi) using a wide range of formulations the creep properties of the different formulations will vary widely. Creep data exists in published form for pure PVC but published data concerning different formulations is more difficult to find and appears to be proprietary. Using an effective stress of 1,800psi is within the range of typical design stresses for the PVC industry. However, it appears that the use of this design stress will require extensive testing and then quality control to insure that the correct formulation of PVC is used which will provide this design strength over the life of the experiment. A more conservative design stress could be used which will require similar levels of testing to determine the correct formulation. However, a lower design stress will allow greater latitude in the formulation during manufacturing as well as greater variations in the extrusion dimensions during manufacturing.