

Nature of Hydrostatic Stress Rupture Curves

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Foreword

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The purpose of this technical note is to provide general information on stress rupture curves used for plastic piping materials.

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I. Introduction

Service life prediction or estimation is an important tool used by design engineers to safely plan, install and operate plastic piping systems. Piping system service life is dependent upon resistance to stress and chemicals from the internal and external environment. Stresses may be internal from pressure or external from embedment, bending or shear. These stresses may be constant or varying. Internal pressure surges, temperature changes, and varying loads from traffic, tidal flows, and the like can also stress the material. Resistance to external or internal chemicals, temperature, and variations in these effects can combine to affect the service life of the piping system.

One component of service life, resistance to stress from constant internal pressure, can be estimated using hydrostatic stress-rupture testing. This Technical Note (TN) explains hydrostatic time to rupture curves, their use, how they are developed under ASTM D 2837 and ISO 9080 protocols, and a brief explanation of the differences between these two methods. This TN is not intended as a guide to determine pressure ratings; the user should consult the appropriate industry standard.

II. The Nature of Hydrostatic Time to Rupture Curves

The testing of pipe samples at different internal pressures in a laboratory environment generates time/stress failure data. However, these data do not form a straight line when plotted on regular graph paper, often called Cartesian coordinates (Figure 1). Detailed studies were performed to determine the best mathematical function to convert the data and the log-stress log-time linear equation was chosen. When plotted on log-log axes, the time/stress failure point data define a straight line, enabling a linear regression analysis (Figure 2). The nature of a time to rupture versus stress hydrostatic curve for a plastic piping material is that as the stress on pipe decreases the time-to-failure increases.

Figure 1 – Stress Rupture Data Plotted on Cartesian Coordinates

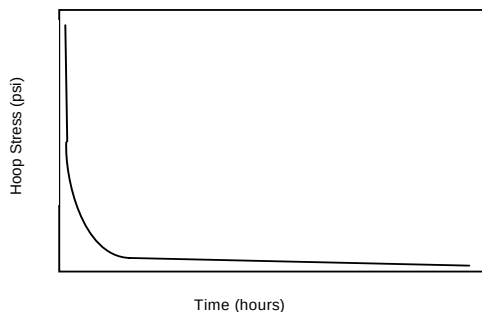
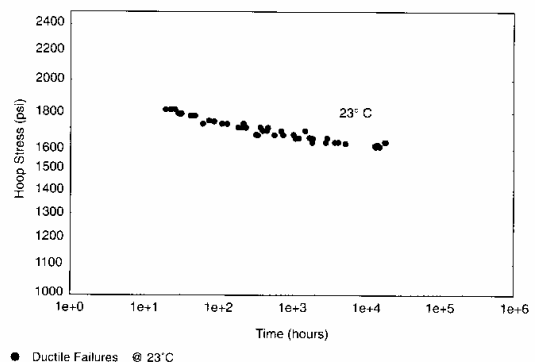


Figure 2 - ASTM D 2837 Hydrostatic Data



By evaluating stress rupture test data from pressure test of pipe made from the subject material, a piping material's stress rating can be determined from the material's ASTM D 2837 Hydrostatic Design Basis (HDB) or ISO 9080 / ISO 12162 Minimum Required Strength (MRS).

The HDB from ASTM D 2837 or MRS from ISO 9080 / ISO 12162 is the categorized long-term hydrostatic strength (LTHS) used to calculate the hydrostatic design stress (HDS) of a plastic piping material. The Plastics Pipe Institute lists the material's HDB and HDS, or MRS value in TR-4, "PPI Listing of Hydrostatic Design Bases (HDB), Pressure Design Bases (PDB) and Minimum Required Strength (MRS) Ratings for Thermoplastic Piping Materials or Pipe".

Hydrostatic testing performed under ASTM or ISO methodologies is applicable to all known types of thermoplastic pipe materials and for any suitable temperature and medium. PPI's TR-4 lists the HDB and MRS values for specific formulations of the thermoplastic materials listed below.

PVC	Polyvinyl Chloride
CPVC	Chlorinated Polyvinyl Chloride
PE	Polyethylene
PEX	Crosslinked Polyethylene
PB	Polybutylene
POM	Polyoxymethylene, polyacetal
PFA	Perfluoroalkoxy
PA	Polyamide, nylon
PVDF	Poly(vinylidene difluoride)

III. Brief Comparison of ASTM and ISO Methods

Both ASTM D 2837 and ISO 9080 analyze stress rupture data to estimate the long-term strength of a plastic piping material. In ASTM D 2837, the HDB for the material is determined by categorizing the mean LTHS value at 100,000 hours (11 years). In ISO 9080, the lower prediction limit (LPL) of the LTHS at 50 years (438,000 hours) is determined then categorized into a MRS as defined in ISO 12162. Both ASTM D 2837 and ISO 9080 / ISO 12162 have served users well for many years. Whether HDB or MRS is determined for a material, the actual long-term performance will be the same under the same service conditions.

While both ASTM D 2837 and ISO 9080 are used to develop hydrostatic time to rupture curves, there are some differences between the methods. Table 1 presents a summary of differences.