TRUPACT I Filtered Pressure Equalization System*

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INTRODUCTION

A filtered pressure equalization system (FPES) for a waste transportation package has been designed and qualified to withstand the package environments induced by the normal and accident condition requirements specified in 10 CFR 71. The use of an FPES reduces the package structural requirements to withstand pressure variations due to gas generation from the payload and elevation changes, and permits the design of a more weight efficient package. The filter is capable of trapping airborne particles, should any be released from the contents to the containment vessel. Particle containment is important for flow from inside the package to outside.

FILTER CONSTRUCTION

Figure 1 shows the configuration of the FPES. The filter cartridge is mounted in a cylindrical stainless steel housing and secured with the filter retainer nut. Silicone O-rings form a seal between the cartridge and FPES housing. The housing is welded to the package containment boundary. The external cover of the filter vent precludes the entry of water. The accumulation of a large quantity of water in the flow passages could be subject to freezing and cause blockage of the ports under extreme conditions.

Figure 2 shows the general configuration of the filter cartridge. The glass fiber filter medium is supplied in sheet form and cut into 2 inch wide strips for the element. A cylindrical element is formed by rolling the strips to form up to 5 wraps of the medium. The inside and outside surfaces of the element are supported by cylinders of stainless steel wire screen. This assembly is bonded into a groove in the stainless

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steel vent end and closed with a stainless steel end cap. The adhesive used is a high temperature two-part silicone. The cartridge is assembled by welding two end assemblies into a stainless steel housing.

QUALIFICATION ENVIRONMENTS

The FPES must function satisfactorily for all normal and accident environments resulting from package exposure to the conditions defined in 10 CFR 71.71 and .73. These conditions produce environments of shock, vibration, pressure, heat, cold, moisture, and air flow.

Normal Environments

Normal environments used in the qualification program included filter temperatures ranging from -40 F to +200 F, air humidities up to 100%, and air flow rates up to 35 liters/minute. Attention was given to the possibility of ice formation caused by humid air flow through a cold filter. Ice formation has the potential for blocking the flow passages and causing unacceptable internal pressures. Approximately 150 experiments were performed to establish that flow through the filter would be sufficient to limit internal package pressure to safe levels for all conditions. Required flow conditions were determined by analysis of potential shipment routes using worst case assumptions of altitude changes, vehicle speed, contents gas generation, and temperature combinations.

Accident Environments

Accident condition environments include shock, air pressure pulse, water immersion, and temperatures to 500 F. Shock and air pressure pulse are caused by regulatory 30 foot drop requirements and were determined by a combination of test measurements and analysis. A shock pulse of 400 g with 2 msec duration was applied to FPES assemblies. An air pressure pulse of 50 psi with a maximum rise time of 12 msec was used to envelope pressure loading. The regulatory 50 foot water immersion requirement causes a water pressure of 21 psig to be applied to the filter. Measurement of temperatures on a TRUPACT I test unit during a 30 minute engulfing pool fire test was used to establish the 500 F upper temperature requirement, with a 5 hour duration.

All accident tests were performed starting at those normal operating conditions which create the greatest likelihood of failure. Due to possible embrittlement or stiffening of the element or adhesive at low temperatures, the shock and air pressure pulse were applied to a filter at -20 F. Also, water in the filter media may significantly increase the flow resistance or reduce the strength of the filter medium, so the shock and pressure pulse tests were performed on filters that had been filled with water to saturate the medium.

FPES assemblies were exposed sequentially to shock, then air pressure pulse, and finally heat to meet the requirements of 10 CFR 71.73 for the sequential accident environments.

FILTER PERFORMANCE

Filtration Efficiency

After exposure to each of these environments in sequence, the filter systems maintained penetrations on the order of 10^{-9}. Filter penetration is defined as the ratio of the number of particles passing through the filter to the number introduced. A penetration of 10^{-9} corresponds to an efficiency of 99.9999999%. Penetration is somewhat dependent on particle size. Figure 3 shows a typical filter penetration characteristic.

Flow Characteristics

The pressure drop across the filter at the maximum flow rate was also measured after each test to establish that the flow restriction and associated package internal pressure had remained within acceptable limits. For these filters, the volume flow rate is directly proportional to pressure drop. Figure 4 shows a typical volumetric flow vs. pressure drop characteristic for one of the filters. The proportionality constant between flow rate and pressure is approximately 40 lpm/psi.

Flow coefficients for cold filters were found to be slightly higher than for the same filters at room temperature. This is explained by the lower viscosity of colder air. The flow coefficient was approximately 9% higher for a filter at -20 F than for one at +79 F.

Water caused a reduction in the flow coefficient of filters. Figure 5 shows flow coefficients for both a dry and wet filter, which was saturated by filling with water.

Leak Rates

The filter cartridge and FPES housing were leak tested and found to maintain leakage less than 10^{-7} std cc/sec air after all normal and accident tests. Leaktight housings assure that all flow is directed through the filter medium.

Conclusion

These results were based on environmental levels established during the TRUPACT I package development program; however, this filter could be used in any application with similar requirements. A more complete description of the filter development is available in the referenced document.

REFERENCE

Kincy, M.A., B.J. Joseph, and D.L. Humphreys. TRUPACT I Filter Development Status Report, SAND88-3271, TTC-0891, Sandia National Laboratories, Albuquerque, NM (1989).

Figure 1. FPES Configuration

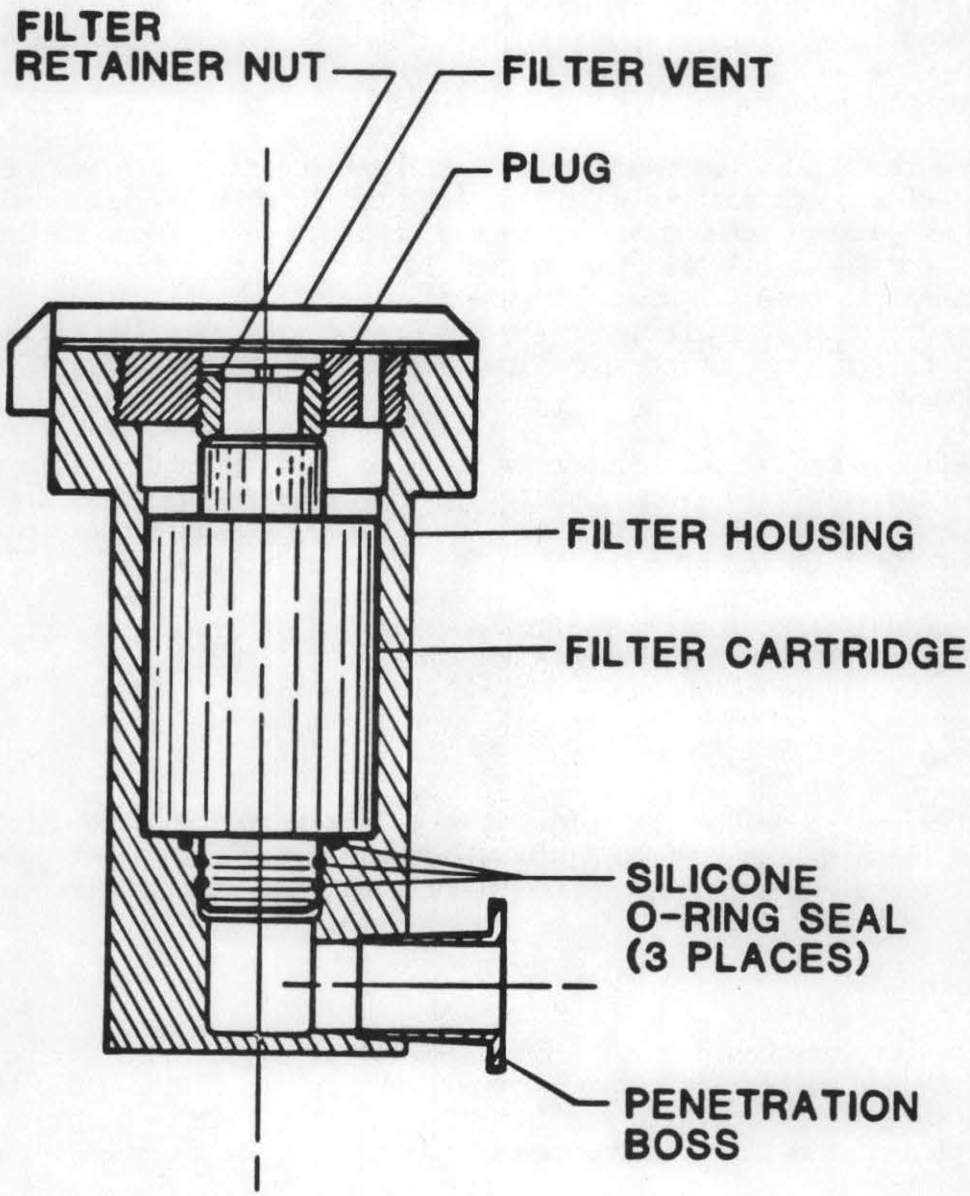

Figure 2. Filter Cartridge Construction

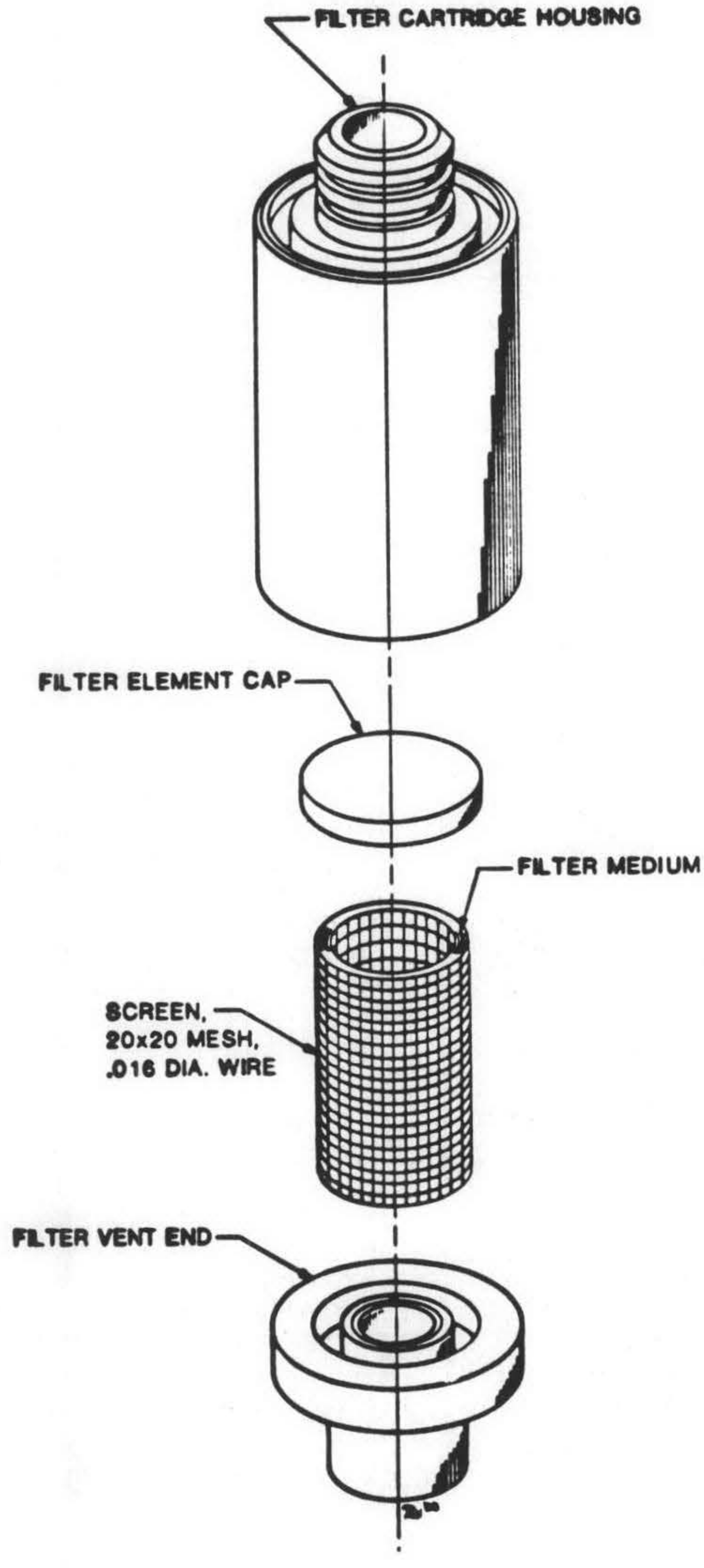

Figure 3. Typical Penetration Characteristics

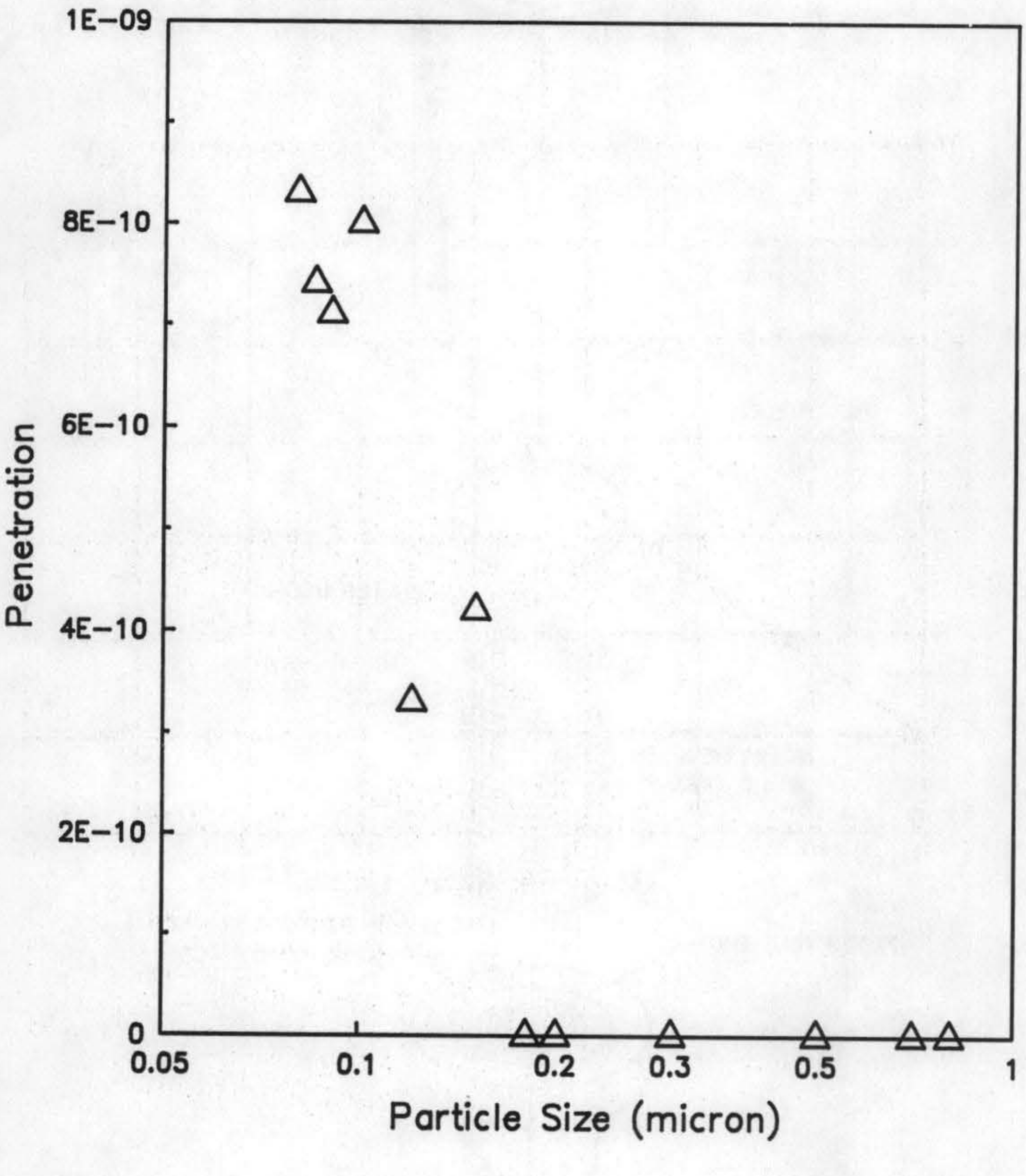

Figure 4. Typical Flow Characteristics

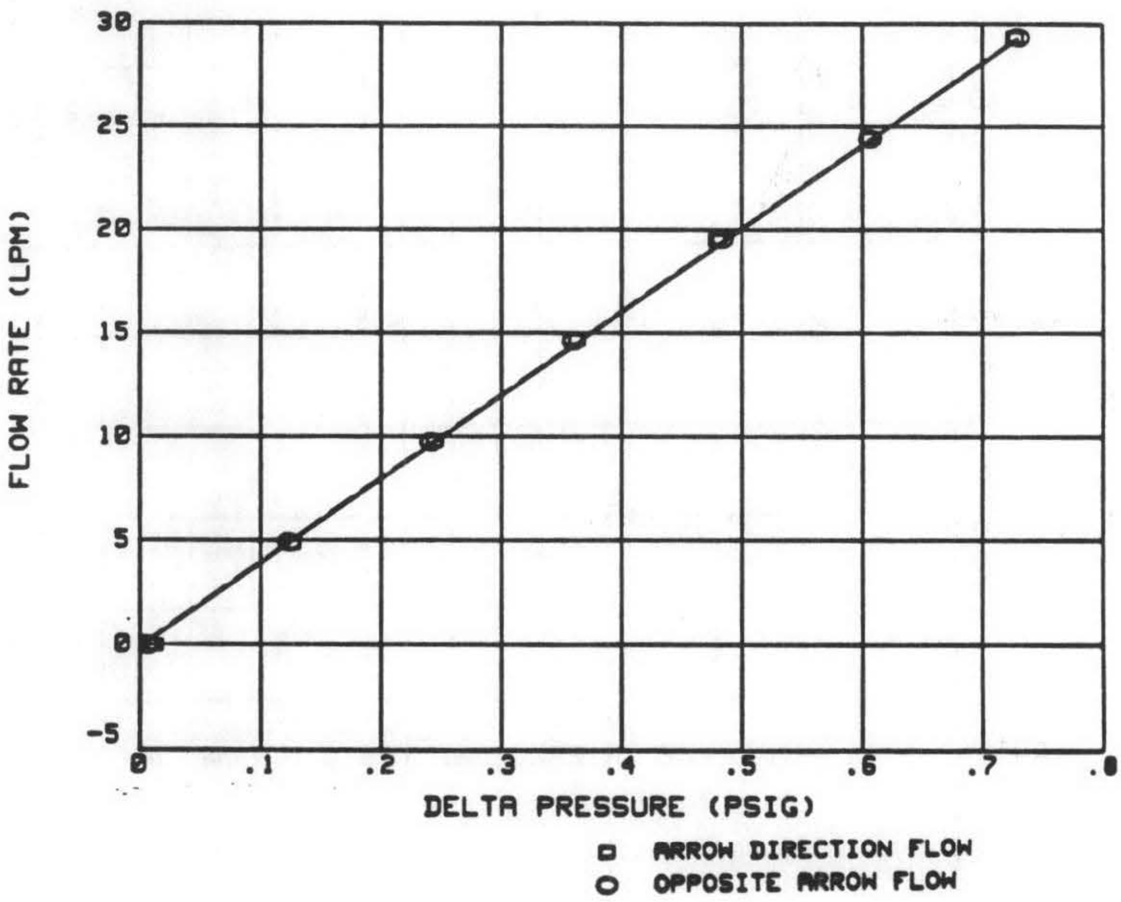

Figure 5. Wet Flow Characteristics