Prepared for:

Taco Inc., Cranston RI

Taco air and dirt separator 4903AD-4

Summary: Efficiency of particle separation

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Report

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1 Introduction

This document is a summary of WL report H4187.05 “Taco air and dirt separator 4903AD-4, Efficiency of particle separation”, outlining the test procedure, test results and practical implications.

2 Product description

The Taco air and dirt separator 4903AD-4 consists of a tank, which is installed in the main line of a pipe system (typically a large heating installation of an office building or hospital). The typical location is immediately downstream of the heating component of the system, in order to exploit the low air saturation concentration at this high temperature.

The main objective of the separator is to separate particles (corroded material, dirt) and air bubbles. The operation of the Taco Air Separator is based on a completely new method of separating gases from liquids (water) by means of special packing bodies called Pall Rings. This new method is in turn based on a long existing, well tried procedure in the processing industry for purpose of mixing gasses or separating them from liquids. The use of Pall-rings in HVAC systems is however entirely new and Patented. The operating principle of Pall rings resides in the special properties which these rings possess namely:

- Large Surface Area
- High probability of coalescention and Adhesion
- Low resistance to fluid flow
- Locally low velocities for particle settling

The construction of the Pall ring is such that all fluid is brought in contact with the total surface of the Pall ring that is available for adhesion. Microscopically small air bubbles present in the fluid come to attach themselves to the contact-surface of the Pall ring. Once these micro-bubbles have grown to form larger bubbles, they float upwards and can be separated from the fluid.

Figure 1: Drawing of the separator

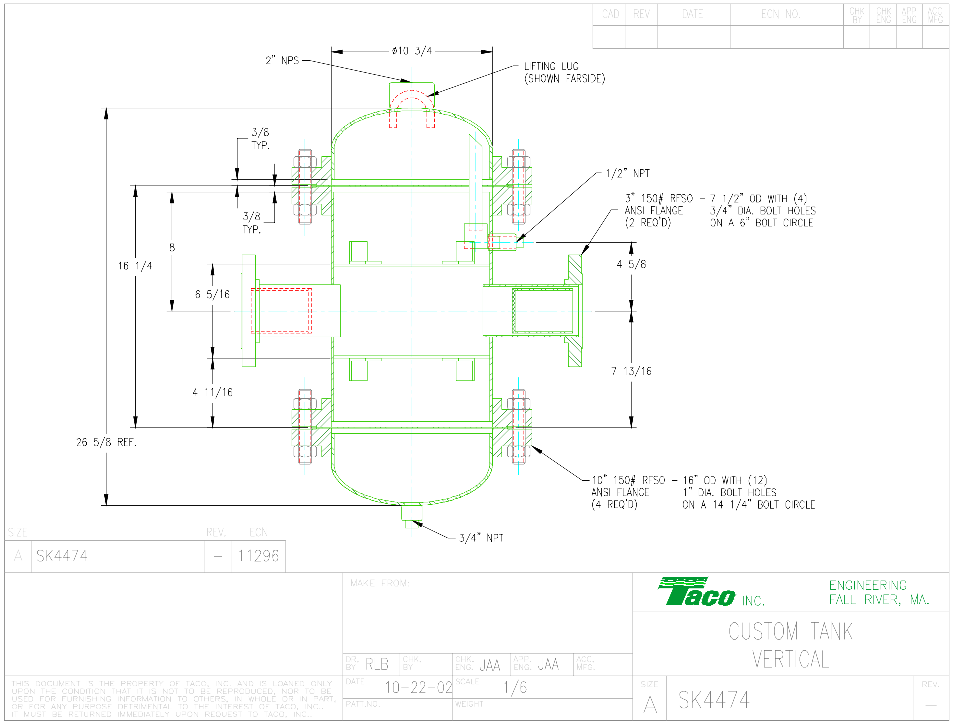
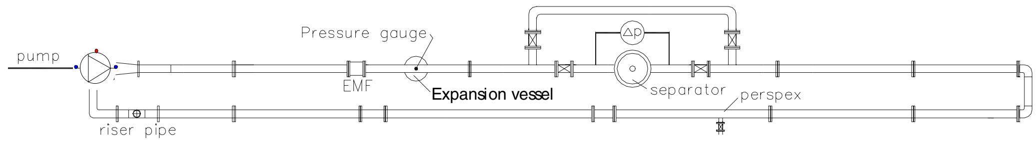


Figure 2: Taco air and dirt separator 4903AD-4 (prototype)

3 Test procedure

The separator is tested in a 50 m long test circuit.



About 200 gram sand with particles up to 300 µm (50% at 125 µm) is inserted in the system through the riser pipe and homogeneously distributed via the by-pass around the separator. During the test a constant velocity is applied. The test starts after fast opening of the separator valves and closing of the by-pass valves. The samples are extracted directly from the system with an in-line sampling device in the perspex pipe. This method allows direct measurement of particles in the system without interruption of the steady flow.

The objective of the test is to determine which particle sizes are separated by the separator and which remain in the system.

The particle size distribution of the samples is analysed with a Malvern 2600/3600 Particle Sizer which is capable of analysing particles in the range of 1 to 1800 microns (10^{-6} m). The optical lens with 300 mm focal length is used for these measurements, which analyses particles in the range of 1 to 500 microns. The analysis method is based on laser diffraction, from which the particle size distribution is derived.

For the analysis we have used the d80 value: 80% of the particles is smaller than the d80 diameter. In each test several samples were taken and measured over a period of 1 to 40 cycles; 1 cycle is the time to circulate through the system at average flow velocity. During a test the d80 diameter drops, because larger particles are separated more quickly.

The following tests have been carried out:
- reference test via the by-pass without a separator with a line velocity of 1 m/s (3.3 ft/s, cycle time is 80 s).
- test via the separator with a line velocity of 0.5 m/s (1.6 ft/s, cycle time is 160 s)
- test via the separator with a line velocity of 1 m/s (3.3 ft/s, cycle time is 80 s) at the inlet of the separator
- test via the separator with a line velocity of 2.1 m/s (7.0 ft/s, cycle time is 37.5 s)
- test via the separator with a line velocity of 3.3 m/s (11.0 ft/s, cycle time is 24 s)

4 Test results

The d80 diameter remains constant during the reference measurements without the separator. This confirms that the test system does not separate particles on its own.

The separation of particles by the Taco separator is realised basically within 10 cycles. The measurements at 1 m/s show that the particle distribution does not significantly change anymore after 10 cycles.

It is concluded from the measurements that the separator removes finer particles from the system, as the line velocity is reduced. The separated particle size (d80 after 10 cycles) is accurately described with a linear curve valid from 0.5 m/s (1.64 ft/s) to 3.5 m/s (11.5 ft/s); see figure 1.

5 Conclusions and practical implications

All particle sizes in the red area of figure 1 are efficiently separated from the heating system by the separator within 10 cycles. The separated particle size decreases as the line velocity at the separator inlet decreases. Particle sizes in the grey area may also be separated, but this separation is not reflected in the tests.

The separated fraction of the particles in a heating system depends on the particle size distribution. If the heating system contains more large particles, then a larger fraction is separated.

For example: Assume that the line velocity at the separator inlet is 1.0 m/s (3.28 ft/s) and the heating system contains corroded material, sand and dirt with a density of 2650 kg/m^3 (sand density) and 98% (by volume) of these particles are greater than 130 µm. Then at least 98% (by volume) of the particles is separated from the system.

Figure 1: separated particle sizes at increasing line velocity