Aerosol Hold Time Calculations in FanTestic Integrity and request for peak pressure data for Aerosol agents

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Retrotec has had requests for a long time to put aerosols into our Clean Agent Integrity software. It has now been included in version 5.8 of FanTestic Integrity. This document details the way the hold time calculations are carried out, and expresses the need for test data in order to be able to calculate peak pressures.

Peak Pressure

We have very little data on peak pressure, so that was left out of the initial version. As long as the enclosure it not much tighter than necessary for the required hold time, there will normally not be a problem but we are requesting test data to develop a peak pressure equation which might be necessary for tight enclosures. A section about the requested test data is included at the end of this document.

Hold Time Calculation

Gravity is one driving force that will create a column pressure whose magnitude is determined by the density difference between aerosol/air mixture inside the enclosure and the air outside the enclosure. We have little or no data on effective column pressures during the 10 minute hold time but since heat is involved we are assuming the initial density is less than the surrounding air and final density at the end of the hold may be greater than the surrounding air due to cooling.

We do not then know with certainty in which direction that agent will leak out. We can deal with this by always assuming the worst case distribution of leaks which would be half at the top and half at the bottom of the enclosure. This leakage split value, F can be then fixed at 0.5 to accomplish that mathematically in the agent loss equation. This also makes the measurement of enclosure leaks much easier since measuring leakage location is difficult.

The maximum magnitude of agent mixture density was assumed to be the application density plus the air density. For application densities of 0.05 kg/m3 to 0.1 kg/m3, the total density when adding in the air density would be 1.204 + 0.05=1.254 and 1.204 + 0.1 = 1.304 kg/m3. Air displaced by the particles would decrease this somewhat but this is a fair failsafe value. This would result in the total pressure due to the height of agent times the density difference would be less than 1 Pa for enclosures up to 4 meters high.

By comparison a temperature increase in the enclosure would reduce the density by 0.03 kg/m3 making it appear that after the temperature evened out in the enclosure, a downward column pressure would cause agent to be lost in that direction for most of the hold time. We still expect some agent to be lost initially from the top of the enclosure within the hot streams from the discharge nozzles. That is taken into account by assuming continual mixing as agent initially is lost upwards and then starts to get lost downwards. Continual mixing assumes that agent remains turbulent for enough time to preclude the formation of a clear interface as happens with halocarbons with an average interface thickness of 0.4 meters and inerts with an average interface thickness of 1.2 meters. Aerosol densities are much closer to that of air when compared to inert agents so it could be safely assumed that no definable interface would form and the assumption that the same concentrations occurred throughout the enclosure was a good one.

While our assumptions for gravity losses may not be correct, it is at least defensible from the standpoint of attainability. An aerosol agent application of a typical 0.07 kw/m3 would result in a density of 1.274 kg/m3 is equivalent to an inert agent concentration of 33.25% which is another way of looking at the enclosure requirements because as the density difference decreases, so does the tightness requirement for the enclosure. By “attainable” we mean that the aerosol enclosure can be a little bit leakier than an inert agent enclosure and still pass the hold time requirement. All hazards need to have some degree of isolation in order to ensure the aerosols will work, so this is at least a good start.

Bias Pressure Losses

Bias pressure caused by HVAC or wind will often be 1, 2 or even 3 Pa. These values will significantly decrease agent concentration whenever HVAC is running during the hold time which is what would be expected. Since we are assuming continual mixing and do not know the direction of loss, we must assume bias pressures are always additive. This will catch enclosures that will have the aerosols sucked out by virtue of bias pressures alone because a fairly typical 2 Pa bias pressure which is often present in building will compromise protection. This new Aerosol hold time prediction will catch those enclosures.

Data Inputs Needed to Use the new Aerosol calculation in FanTestic Integrity

NPFA 2010, 2010 Edition requires an Enclosure Integrity evaluation to be performed. The analysis requires:

Enter: “Net Protected Volume” (m3 or ft3) which is the flooded volume.
Enter: “Agent Quantity” (kg or lb) which is the total flooding quantity
Integrity calculates: “Initial Application Density” = Agent Quantity (kg or pounds) / Volume (m3 or ft3)
Enter: “Minimum Density” (kg/m3 or lb/ft3)

Enter: specified Hold Time (defaults to 10 minutes)

Integrity calculates Hold Time = time for Initial Application Density to fall to Minimum Density (MD). Assume that extinguishing density is always less than MD.

Density cause gravity losses due to the addition of the total mass of agent + HVAC losses due to Static pressures across enclosure.

Assume:
- Settling rate of particles is much longer than hold time.
- Thermal affects are minimal or at least no greater than the density increase assumptions.
- Even concentration within enclosure
- Want hold times up to 60 minutes.

Instrumented Test Data Needed to implement Peak Pressure calculations

Peak Pressure created during discharge and Agent Retention times are essentially unknown. To follow in the footsteps of NFPA 2001, which has documented both and changed predictions equations as a result, we propose a similar test regime. Retrotec has four years' experience handling the instrumentation and data collection for both results.

Proposed Test Regime

While installed systems can provide useful data, it is better to engineer the test chamber to get the most useful data. In either case it is important to have an enclosure that has known leakage and known leakage location.

A 4 meter cube or something close to it is ideal. Height should be close to the maximum that would typically occur so we can observe any gravity effects which we suspect could be an initially lower density causing the mixture to rise, followed by higher density upon cooling due to the particulate load. I confess that I don't know if these particulates would increase density or not.

The enclosure should have a series of holes at the top and bottom of the enclosure equally spaced around the perimeter to let air flow in and/or out smoothly and symmetrically. One inch diameter is about right. Two channels of pressure gauges with pickups measuring the differential across the enclosure at the top and bottom will suffice to measure both peak pressure and column pressure that would develop during the discharge and say 30 minutes into the hold time. Total leakage must be measured with a door fan using the NFPA method. Since the number of holes at the top and bottom will be equal, the leakage distribution will be 50/50 assuming the background leakage of the chamber is low. The background must be measured prior to drilling the holes or with all holes plugged to ensure the location is known exactly.

A means for measuring agent concentration with respect to time is important.

Retrotec would supply 4 channels of pressure acquisition equipment that will measure pressure to a 0.1 Pa resolution up to 1245 Pa. Acquisition would be greater than 5 readings per second but averaged over 1 second intervals. In this way, flow from upper and lower holes can be measured independently for the duration. Column pressure will be known from the total of the upper and lower differentials.

A means for measuring temperature at the top, bottom and middle of the enclosure should be provided.

Agent discharge time, initial agent quantity and minimum agent quantity must be documented.

We suggest not having an active fire in the enclosure on the assumption that the suppression system would put out the fire long before sufficient heat would be produced. It is well known that heat from a fire would dramatically increase buoyancy and create a pressure on the top of the enclosure.