PREVENTING EXCESSIVE ENCLOSURES PRESSURES DURING CLEAN AGENT DISCHARGES

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INTRODUCTION

The discharge of a total flooding gaseous fire extinguishing system into an enclosure creates large peak pressure fluctuations against the boundaries of the protected space. Infrequently, the enclosure may suffer minor to major damage when there are not enough holes and/or vent dampers to safely relieve that pressure.

The numerous parameters that affect the peak pressures can be combined into a few Vent to Volume Ratios (VVR) that can be used to specify how much vent area is needed in any enclosure to keep the peak pressure below a specified value. A test program is under way to verify existing VVR values, to expand the parameters covered and to add new agents. This paper will demonstrate how a procedure similar to the Enclosure Integrity Procedure section of NFPA2001 could eliminate the possibility of enclosure damaging pressures.

ACKNOWLEDGEMENTS

Many thanks to Brad Stilwell of Fike who has generously offered to test all agents under identical conditions in their lab and to Joseph Senecal of Kidde Fenwal who has been invaluable in offering scientific guidance and perspective.

WHAT IS A PEAK PRESSURE?

Gaseous fire extinguishing agents are either inert gases or halogenated hydrocarbons. The discharge of an inert agent system will create an immediate rise in pressure within the enclosure, creating one positive peak value before dropping off after a few seconds. CO_2 is an exception, where the peak occurs towards the end of the discharge. On the other hand, the discharge of most halocarbon agents will result in an initial decrease in enclosure pressure (due to evaporative cooling) followed by a rise in pressure. A decidedly more complex pressure-time event! In Figure 1, the pressure fell to a negative peak value of -387 Pascals then rose to the positive peak value of +671 Pascals before falling back down to 0, about 10 seconds after the end of the 5.5 second discharge.

The enclosure must be capable of withstanding both of these Peak Pressures without damage.

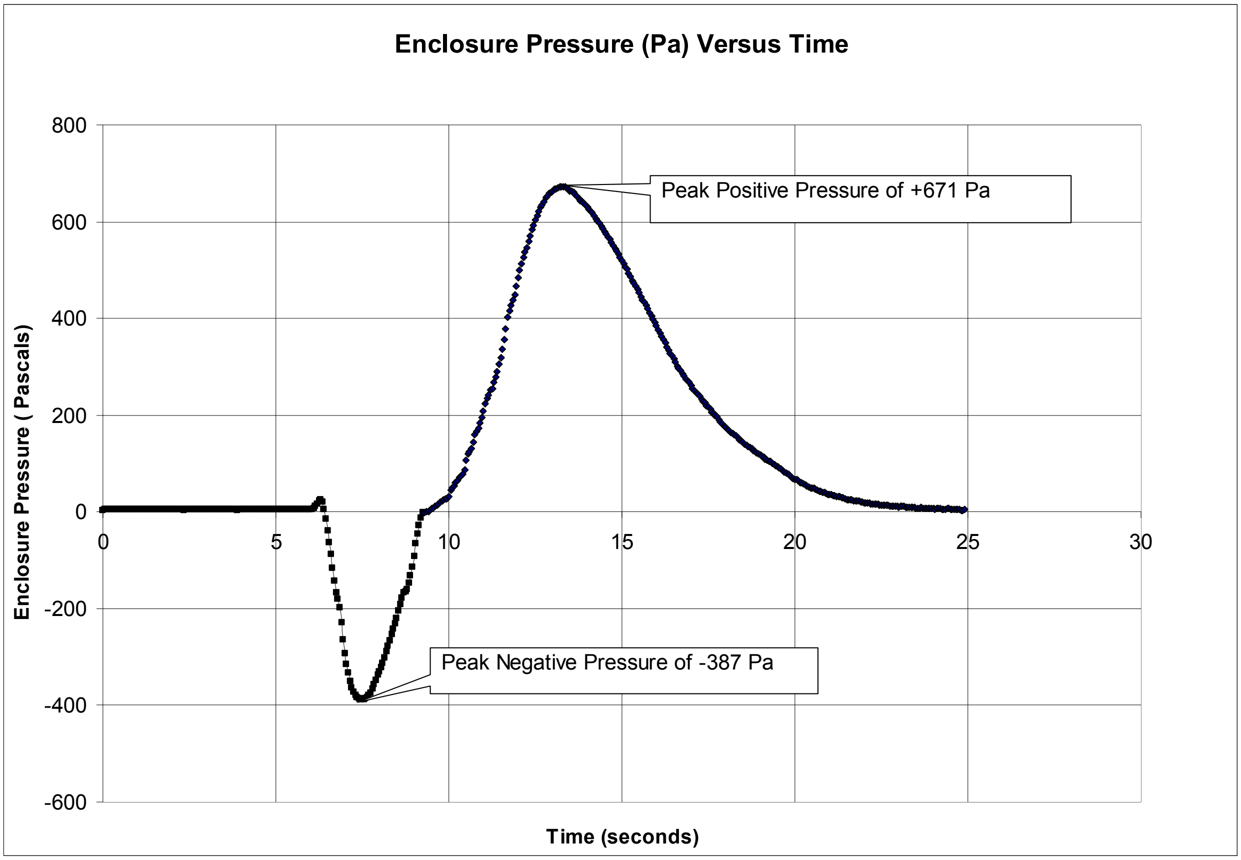

Figure 1. Example of an actual HFC-227ea Discharge showing Peak Pressures.

MAXIMUM PRESSURE THE ENCLOSURE CAN WITHSTAND

Studies are currently underway to give designers more information to allow them to specify the maximum positive peak pressure that the enclosure can withstand without damage. Some halocarbon agents may have negative pressures greater than the positive peak pressures, requiring a specification for both. Either way, the designer must specify the maximum allowable peak pressure for each installation. Currently, 250 Pa for average walls and 500 Pa for stronger walls are used.

Based on our observations of typical retention times, it is clear that enclosures are regularly experiencing pressures well in excess of 500 and even 1000 Pa! This implies that enclosures are capable of absorbing much greater pressures than has been assumed, or that many enclosures are being stressed unduly by discharges, and/or that many enclosures in existence will get damaged when a discharge occurs. Consider that the 37.5% inert agent discharge in Figure 4 creates about 250 Pa and has a 10 minute retention time based on 50% lower leaks. If the retention time of this typical enclosure goes up to 20 minutes as they often do, then the peak pressure goes up to 1000 Pa. Since inert agent enclosures are frequently discharged and their retention times are frequently above 20 minutes, it is likely that many enclosures have been experiencing in excess of 1000 Pa regularly without a problem.

VENT AREA NEEDED TO CONTROL PEAK PRESSURES

The Peak Pressure created in the enclosure depends on a number of parameters, but primarily upon the agent type, agent concentration, discharge time, humidity range, opening characteristics of the valve, wall construction, and the vent area of the enclosure. All these parameters have an affect but the most important is the vent area of the enclosure, which is taken to mean openings whether unintentional and/or operable and/or intentional. No matter what the other parameters are, an extremely leaky enclosure will produce an extremely small pressure and an extremely tight enclosure will produce and extremely high pressure. To be able to specify this vent area for enclosures of any volume, a ratio can be made between vent area and volume. The other variables can be fixed so that the one ratio can be used to dictate the vent area needs of any enclosure. This ratio would be defined as the Equivalent Vent Area of the enclosure under discharge conditions divided by the volume of the enclosure given the set discharge parameters such as can be seen in Table 6. This could be called the Vent to Volume Ratio or VVR. Table 1 shows a group of nine VVR values for a ten-second discharge of HFC-227ea in a humidity range of 30-60%, with a valve that fully opens on discharge and a temperature range of 10°-30ºC. Each peak pressure/concentration combination would have one VVR associated with it.

Table 1. VVR Table for 10 Second HFC-227ea Discharges.

HFC-227ea	Vent per Volume Ratio (VVR) for Peak Pressures of:		
Concentration	+250 Pa	+500 Pa	+1000 Pa
%	cm^2/m^3	cm^2/m^3	cm^2/m^3
5.65	**3.8**	**1.8**	**1**
7	**3.6**	**1.8**	**1**
9	**5.5**	**3.1**	**1.8**
Conditions: 10 second discharge, humidity range 30 to 60%, valve fully opens on discharge, temperature range 10 to 30 C.			
NOTE: Values shown are approximations, are yet to be verified, and are presented here to facilitate understanding of the concepts. Values are not for field use.			

Table 1a. Halocarbon Example of a vent area calculation using the VVR Table.

Enclosure Volume	100 m^3	Agent	HFC-227ea
Wall Strength	-250/+250	Discharge Time	10 seconds
Relative Humidity	30 to 50 %	Initial Concentration	7%
Valve opening characteristic	fully	Temperature	20°C

VVR from Table 1 (opposite 7% and below 250 Pa) = 3.6 cm^2/cm^3
The minimum allowable vent area to ensure the pressure does not go above 250 Pa would be:
3.6 cm^2/m^3 X 100 m^3 = 360 cm^2

In this example, the designer can specify that the vent area in the discharge condition must be 360 cm^2 or more to keep the peak pressure below 250 Pascals. This would include the unintentional leaks in the enclosure plus any added relief dampers, if any. When the technician tests this enclosure, a measurement of 360 cm^2 or more would give the enclosure a “pass” from a venting standpoint. Figure 2 shows exactly the same data for the same parameters as in Table 1. The VVR must be above the "+250 Pa Peak" line to keep the peak pressure below 250 Pa. *Values shown are approximations, not yet verified, and are presented here to facilitate understanding of the concepts.*

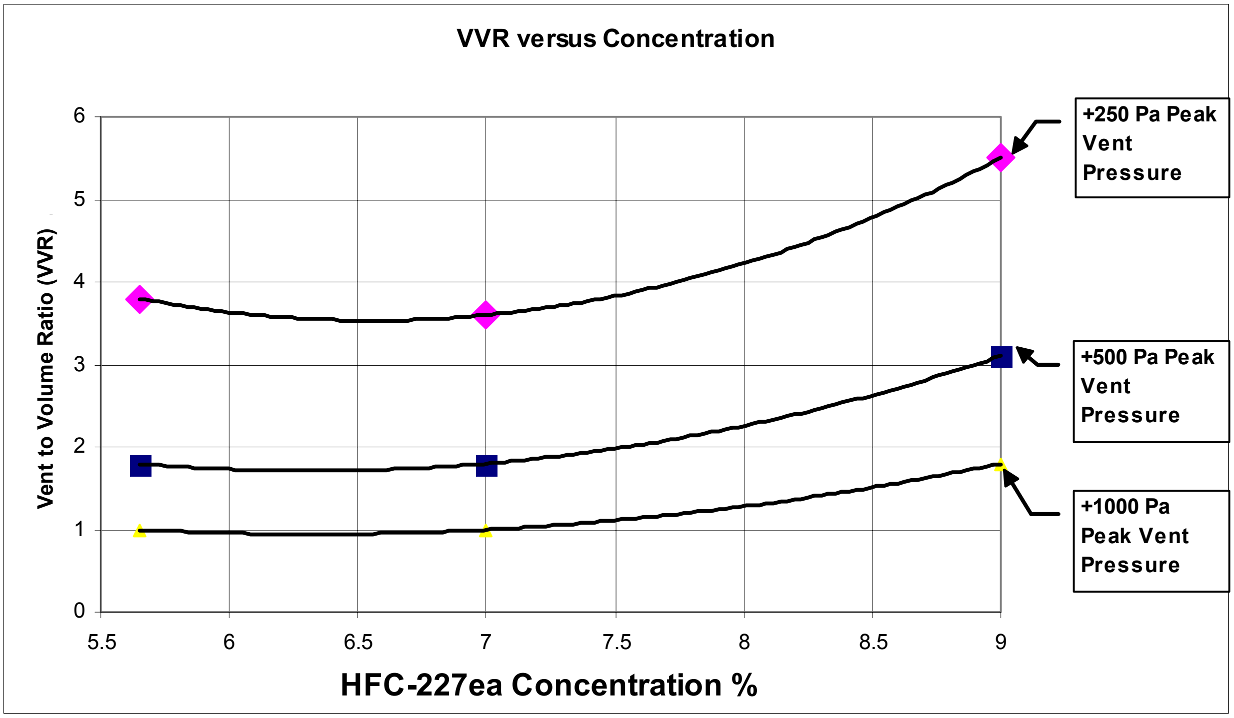

Figure 2. Graph of 10 Second HFC-227ea Discharge versus VVR.

One currently used VVR value for 7% discharges in ten seconds is 4.4 cm^2/m^3 but this value has a 20% safety margin included for peak pressures of 5 lb/ft^2 (239Pa). The value of 3.6 cm^2/m^3 in Table 1 corresponds to this very closely when the safety factor is removed.

By comparison, inert discharges require a much higher VVR as shown in Table 2. This same data is shown in graphical form in Figure 3.

Table 2. VVR Table of 60 Second Inert Gas Discharges.

Inert Agent	Vent Area per Volume Ratio (VVR) For Peak Pressure of:		
Concentration	+250 Pa	+500 Pa	+1000 Pa
%	cm^2/m^3	cm^2/m^3	cm^2/m^3
28.6	**6.9**	**4.9**	**3.5**
37.5	**9.8**	**6.9**	**4.9**
42	**11.4**	**8.0**	**5.7**

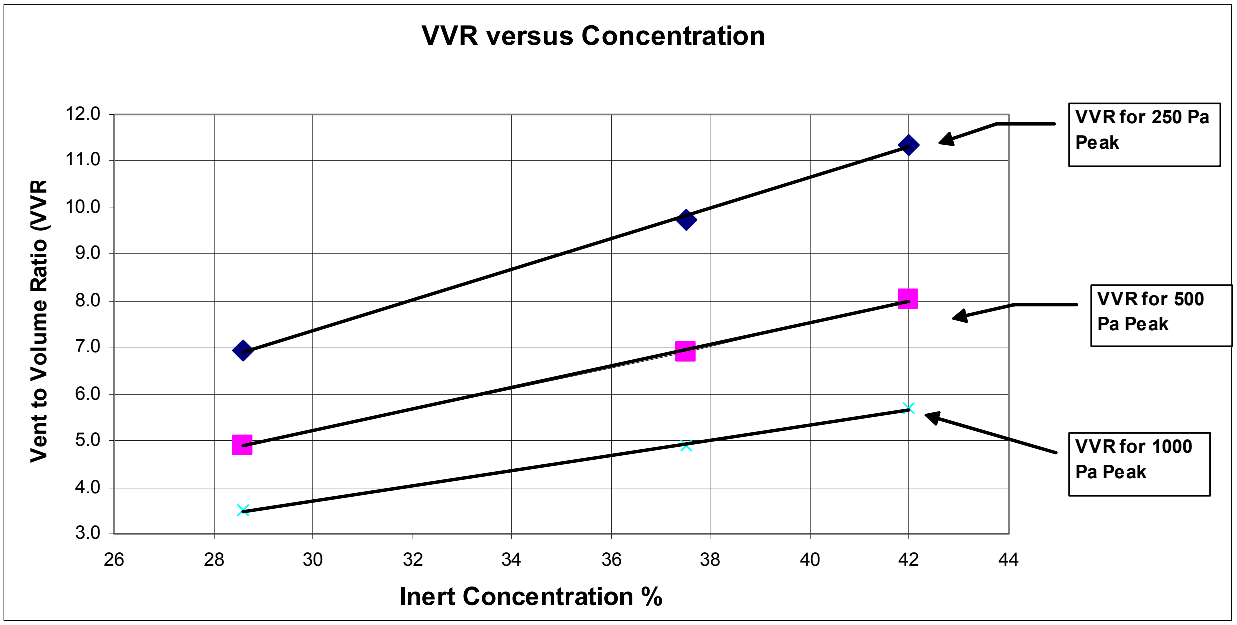

Figure 3. Graph of 60 Second Inert Agent Discharge VVR Data.

Table 2a. Inert Example of a vent area calculation using the VVR Table.

Enclosure Volume	100 m^3		Agent	Inert
Wall Strength	-250/+250		Discharge Time	60 seconds
Relative Humidity	N/A		Initial Concentration	37.5 %
Valve opening characteristic	fully		Temperature	20°C

VVR from Table 2 (opposite 7% and below 250 Pa) = 9.8 cm^2/cm^3
The minimum allowable vent area to ensure the pressure does not go above 250 Pa would be:
9.8 cm^2/m^3 X 100 m^3 = 980 cm^2

The inert agent requires more vent area than the halocarbon to keep the peak pressure below 250 Pa. Based on a 100 m^3 enclosure, the halocarbon requires 360 cm^2 of vent area to achieve a 250 Pa peak whereas the inert will reach 250 Pa with 980 cm^2; it is apparent why inert agents have the unfair reputation for creating excess pressure. Given the same enclosure, inert agents create more peak pressure than halocarbons. As long as the enclosures are not measured for leakage, a random selection of installations will always show the inert producing more pressure. In reality, when the enclosure is tightened to the same degree for agent retention, both halocarbons and inerts create similar peak pressures as shown by comparing Figures 4 and 7.

There could be as many VVR values published, as there are configurations of parameters. But the addition of the VVR values for negative peak pressures per Table 4, plus another table for a six- second discharge may be all that would be necessary for a halocarbon. CO_2 and the inert agents would require a similar array of tables but would not need negative values because they don't appear to create significant negative pressures.

HOW IS THE VVR OF AN ENCLOSURE MEASURED?

First, Equivalent Vent Area of the enclosure must be measured. This vent area is simply the sum of all the intentional holes, unintentional holes and vents measured together with a calibrated flow measuring door-fan designed for that purpose. This flow is converted to an equivalent hole that would give the same flow at the test pressure. This vent area is then simply divided by the volume to get the VVR.

The door-fan test procedure in NFPA 2001 Annex C is familiar to most installers of clean agent systems and provides a good basis for a vent test procedure with a few minor modifications. Most clean agent installers already possess the necessary door-fan test equipment and know how to use it.

RESOLVING VVR CONFLICTS FOR VENTING VERSUS RETAINING AGENT

The designer's challenge is to resolve the conflict where on one hand, the enclosure must be leaky to prevent the peak pressure from going too high and on the other, the enclosure must be tight enough to ensure the agent stays in the enclosure for the typical ten minutes of retention time. For many inert agent systems the solution to venting is to just add a relief damper to ensure there is sufficient vent area to relieve the pressure. Adding the proper size vent can solve the problem but in other cases the cost to install the vent damper may be prohibitive and/or not possible. Another approach is to ensure the enclosure has sufficient unintentional or passive leaks for venting but not so much that it will fail the retention time test. The enclosure would be sealed until the vent area was in the solution space where the requirements for both retention and venting were satisfied.

Figure 4 demonstrates this principle. The specified peak pressure is 250 Pa forcing the VVR to be above the "250 Pa Peak" line and ten minute retention time forces the VVR to be below the "ten-minute retention" line. These create a triangular Solution Space where both the peak pressure and retention conditions are satisfied. The ten minute retention time curve will differ for all enclosures but in this case the retention time line is dictated by the 3.2 m high enclosure where the leaks are located in the worst case position; 50% ceiling and 50% floor and the protected height is 2.4 m. Below this Solution Space, a vent would be needed. Above this space, the ten-minute retention time cannot be met.

Figure 5 shows one way to increase the Solution Space by increasing the specified peak pressure from 250 to 500 Pa.

Figure 6 demonstrates increasing the Solution Space still further by using an inexpensive Below Ceiling Leakage Area (BCLA) measurement to quantify the lower leaks, yielding a much longer predicted retention time. A more common but riskier and more costly method is to discharge test the enclosure to verify the longer retention time.

Figure 7 shows the same enclosure but depicts the VVR requirements for HFC-227ea. The Solution Space is similar to that of the inerts except it all happens at lower VVR values. The longer 20 minute retention time forces the enclosure to be much tighter, increases pressure and eliminates the Solution Space forcing changes.

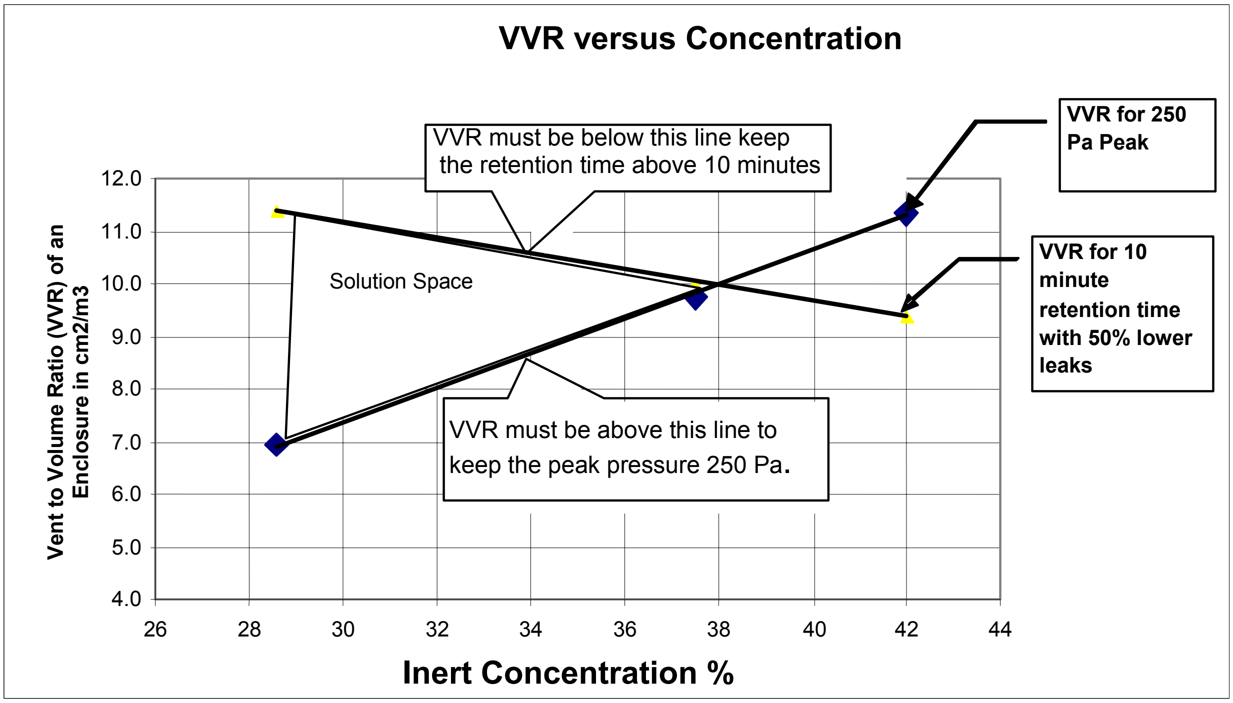

Figure 4. Graph of an Inert Gas at 250 Pa Peak Pressure and ten-minute retention time curves.

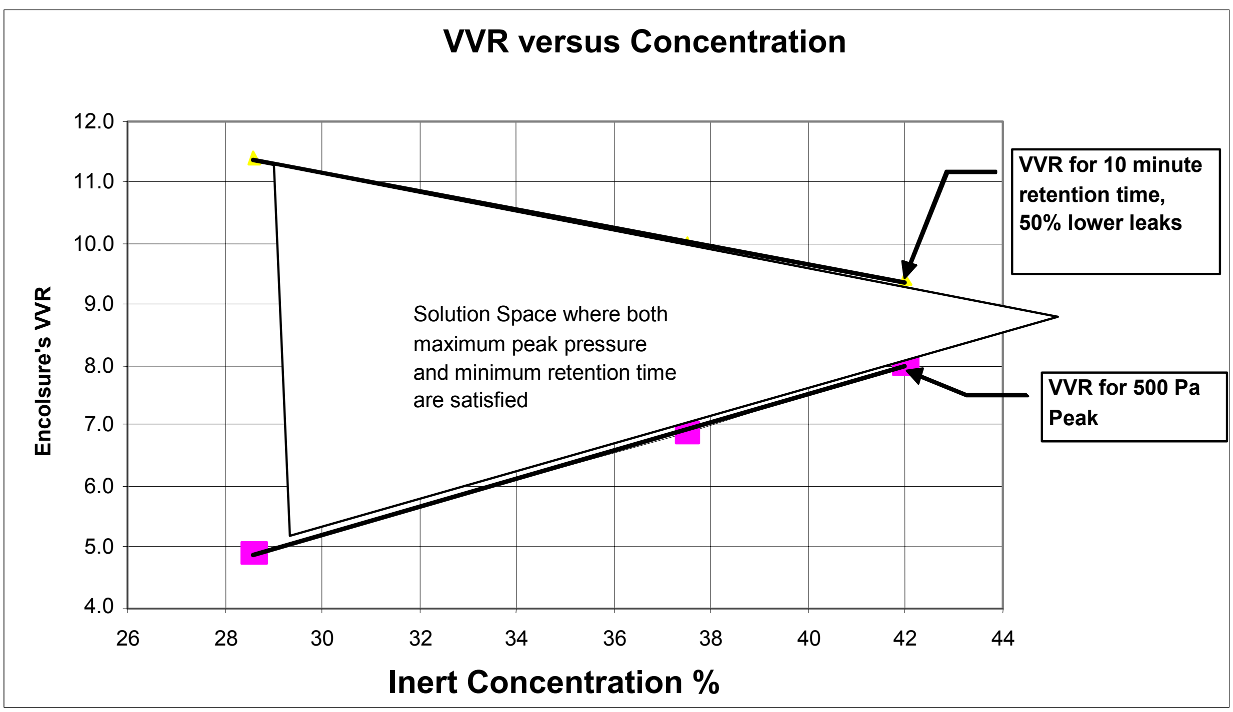

Figure 5. Increasing Peak Pressure to 500 Pa allows a wider range of VVR.

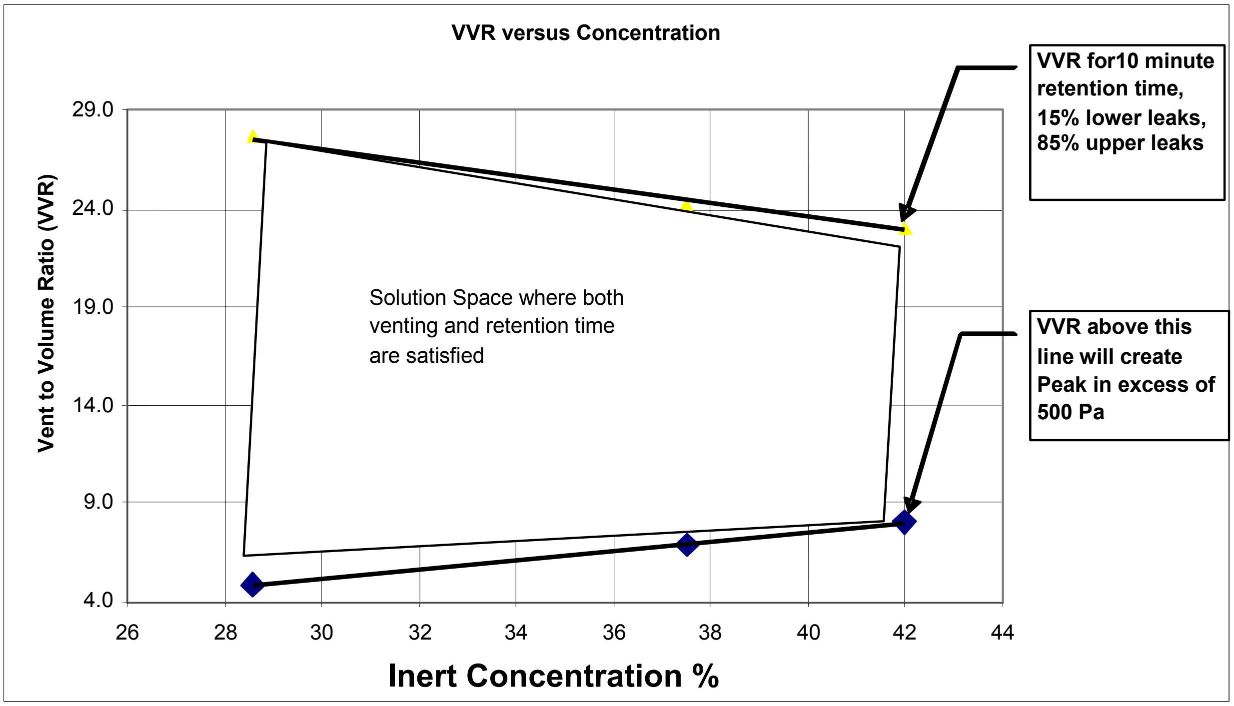

Figure 6. Changing the Leakage distribution increases the range still further.

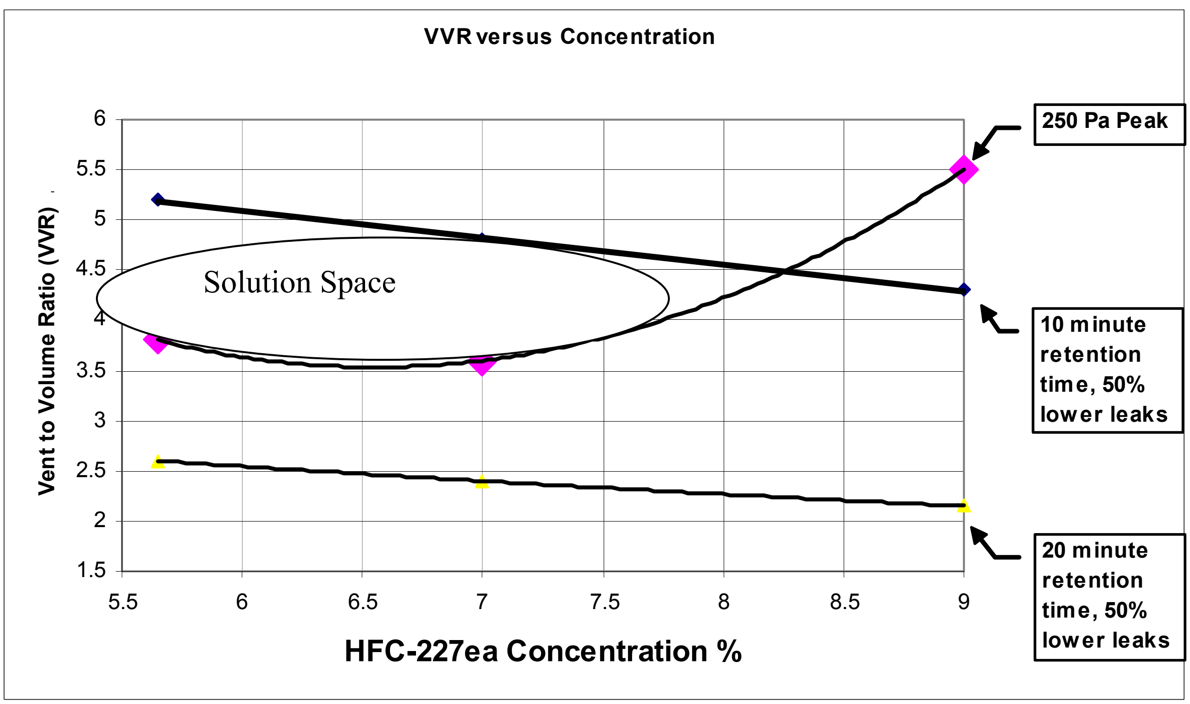

Figure 7. HFC-227ea for 250 Pa Peak with 10 and 20 minute retention times with 50% lower leaks.

Understanding the Solution Space is essential for designing enclosures either without vents or for deciding if vents are needed, and if so, what size they should be. There follows the best and the worst case for the same enclosure with a few changes. Figure 8 shows no need for an added vent in the Solution Space whereas Figure 9 has no Solution Space and must have a vent added.

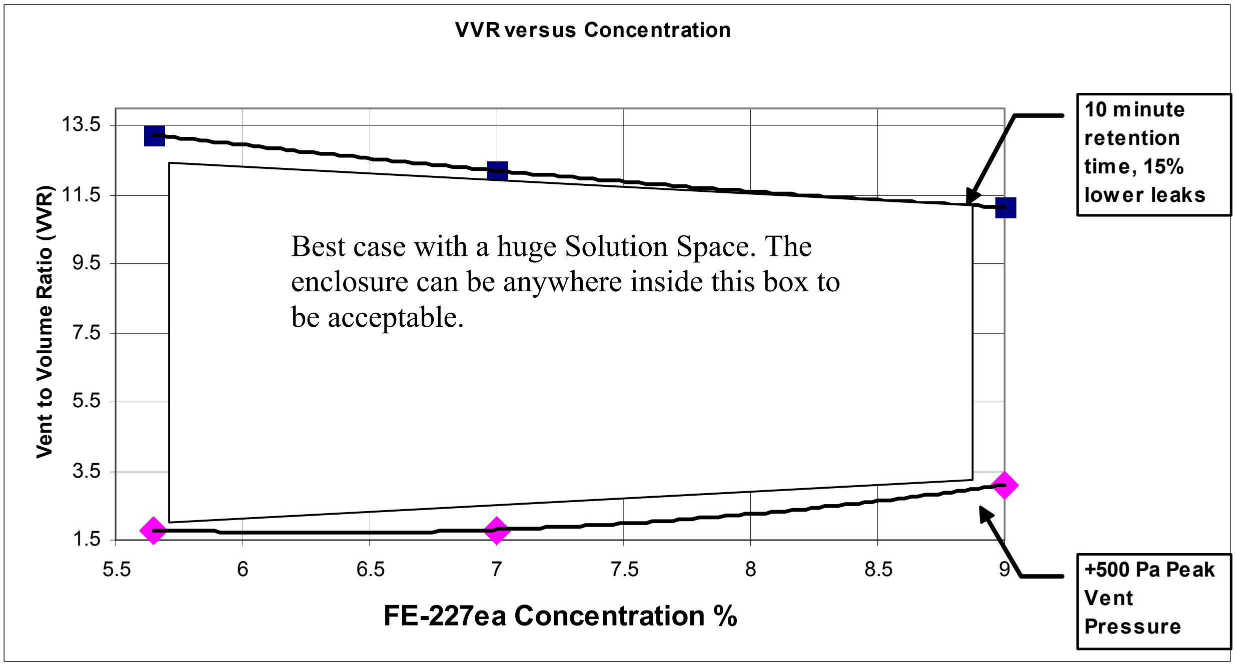

Figure 8. Increasing peak to 500 Pa measuring lower leaks at 15% widens the space.

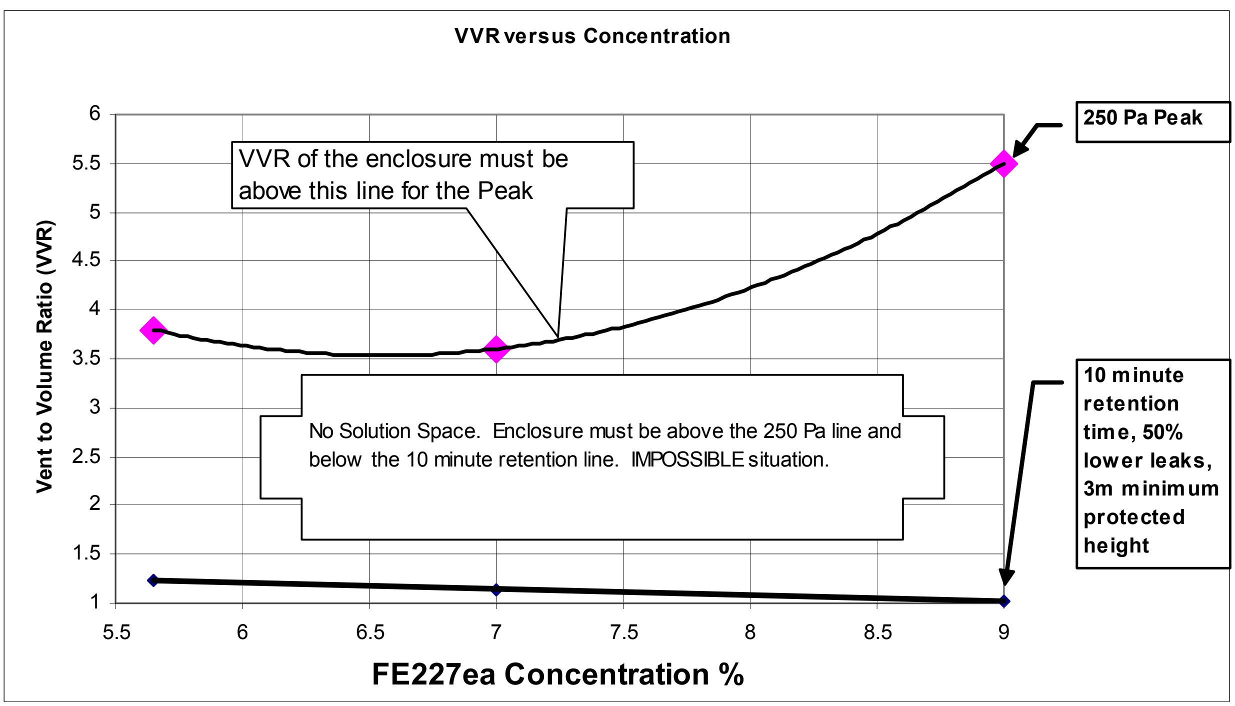

Figure 9. 250 Pa Peak Pressure Protection to 3 meters forces a vent to be added.

PROPOSAL TO CREATE AN ENCLOSURE VENT CAPACITY PROCEDURE

The Vent Capacity Procedure must require the designer to specify the Maximum Peak Enclosure Pressure allowable based on the envelope perimeter strength of the enclosure, including the ceiling. The peak pressure will impact ceiling tiles unless they are vented.

Measure the Equivalent Vent Area of the enclosure in the same manner as the Equivalent Leakage Area is currently being measured in Annex C with the following exceptions:

- Make all measurements at 60 Pascals instead of the 10-15 Pa required by NFPA 2001 Annex C because:
    1. Higher test pressure is more accurate/representative for venting since it more closely approximates the pressure where the enclosure will be venting pressure
    2. Most installers already own door fan equipment that will test to 60 Pa
    3. 60 Pa will produce a vent area that is slightly smaller than if it were taken at a higher pressure, making it conservative by under-measuring the vent area.
    4. Gravity dampers should open at 50 Pa to ensure the enclosure gets vented as quickly as possible to accommodate the very brief spike. Testing at 60 Pa allows these dampers to be checked and their installed capacity measured.
    5. 60 Pa will not pull down suspended ceilings although it will cause them to creak if there is a lot of leakage on the other side.
- Electronic and/or pneumatic dampers that will normally be open prior to the peak pressure created by the discharge must be actuated. Allow gravity-style dampers to be opened by the 60 Pa test pressure.
- Measure the Vent area in only the Positive direction for inerts and CO_2. Measure the Vent areas in both directions for halocarbons. NFPA 2001 requires a test in the positive and negative directions that are then averaged to overcome the background (static) pressures of 1,2 or 3 Pa that are often present during the test. This averaging will not be necessary for relief vent testing since the higher test pressure will effectively mask these small bias pressures. Measuring the Vent Area in the direction of the expected pressure is a more important consideration because there may be more venting in one direction than the other. Halocarbons have both a positive and a negative pressure swing, and the vent area of both needs to be assessed. Inert gases and CO_2, on-the-other-hand only have a positive peak pressure to be concerned with.

Manufacturers of agents should be tasked with establishing Vent Area to Enclosure Volume Ratios (VVR) for all parameters they feel are relevant for their agents. Consideration should be given to whether additional tables should be provided for different wall materials since some may flex and reduce the magnitude of the pressure. Different styles of discharge apparatus may give very different results so consideration should be given whether to establish tabular values based on the equipment or just a set of more general values that relate only to the agent.

These VVR values could then be used to evaluate an enclosure by dividing the total Equivalent Vent Area by the volume into which the agent is intentionally discharged. If the VVR measured for the enclosure is greater than the tabulated value for the enclosure, the enclosure passes, if not it fails. When an enclosure fails, more vent area must be added either as a fixed vent in the upper part of the enclosure, or and openable vent that would be actuated upon discharge.

WORKED THROUGH EXAMPLES

FROM THE DESIGNER'S POINT OF VIEW

The example in Table 3 can be analyzed using the VVR values in Table 4.

Table 3. Designer's Example Enclosure.

Enclosure Volume	350 m^3	Agent	FE-227ea
Maximum Protected Height	4 m	Discharge Time	10 seconds
Minimum Protected Height	3m	Initial Concentration	7%
Wall Strength	-250/+250	Required Retention Time	10 minutes

Table 4. VVR Table of 60 Second Inert Gas Discharges.

	HFC-227ea, 7% concentration in 10 seconds						
	Vent to Volume Ratio (VVR) in cm^2/m^3 for a Peak Pressure of:						
Concentration	**-1000 Pa**	**-500 Pa**	**-250 Pa**		**+250 Pa**	**+500 Pa**	**+1000 Pa**
%							
5.65	-1.1	-1.8	-3.4		3.8	1.8	1
7	-1.3	-2	-3.5		3.6	1.8	1
9	-2	-3	-5		5.5	3.1	1.8

Table 4 shows that the Vent to Volume Ratio for a 7% concentration of HFC-227ea at 250 Pa peak is -3.5 and +3.6 cm^2/m^3. Choosing only to focus on the peak positive value of +3.6, this yields a minimum allowable vent area from the enclosure and/or relief dampers of:

$$3.6\ cm^2/m^3 \times 350\ m^3 = 1{,}260\ cm^2$$

Assuming there are no vents and that the leakage distribution is the worst case for retention time (50/50) then using NFPA 2001, Annex C (or third party software), the retention time can be calculated to be: 11.9 minutes. No vent is required if the enclosure is tightened until the vent area is reduced to 1,260 cm^2 but there is a small margin between this 11.9 minutes and the minimum ten minutes that are required. If extra leaks occur in time, as they always do, the enclosure would fail to hold concentration. Another part of the designer's specification could be to require leak distribution measurements while the airsealing is taking place. Where the primary focus was the lower leaks, it could then be expected that the lower leaks may be reduced to 25% of the total, causing the retention time to increase to 16.8 minutes, thereby accomplishing a long retention time and sufficient venting without installing vent dampers.

FROM THE SYSTEM INSTALLER'S POINT OF VIEW

By way of example, a system installer would follow these steps prior to completion of the installation to ensure the Peak pressure would not be exceeded.

Table 5. Designer's Example Enclosure.

Enclosure Volume	500 m^3	Agent	HFC-227ea
Wall Strength	-250/+250	Discharge Time	10 seconds
Relative Humidity	30 to 50 %	Initial Concentration	7%
Valve opening characteristic	fully		
Maximum Protected Height	7 m	Required Retention Time	10 minutes
Minimum Protected height	6 m	Calculated Retention Time	17.9 minutes

The vent area was measured at 500 cm^2 after air-sealing the enclosure.
To establish the VVR: $500cm^2/500m^3 = 1.0\ cm^2/m^3$

This VVR of 1.0 is below the minimum specified for 250 Pa of +3.6 and -3.5 so the enclosure fails (it is too tight and damaging pressures could result upon discharge). The actual pressure generated from a VVR of +1.0 would be +1000Pa and in excess of -1000 Pa on the negative side. These are precisely the situations the guidance is designed to spot. The retention time is 17.9 minutes and does not give much warning that anything is amiss. The clue is in the high minimum protected height that requires the enclosure to be very tight to achieve retention at this level.

Possible Solutions:

1. Table 5 shows that 3.6 cm^2/m^3 are required to reduce the peak down to 250 Pa. One solution would be to add a relief damper that has an area of: $3.6-1.0 = 2.6\ cm^2/m^3 * 500\ m^3 = 1300\ cm^2$.
2. Increase wall strength to just over 1100 Pascals.
3. Another solution would have been to seal the lower leaks to increase retention time while maintaining sufficient upper leaks for venting. The ongoing dilemma of sealing leaky enclosures only to be then forced to install a relief vent can be solved by the selective sealing of lower leaks followed by leakage distribution testing.

GOOD VENT DESIGN PRINCIPLES

TEST DON'T GUESS

As previously discussed, there is a very narrow margin between needing a vent and not needing one and there is no way to guess that an enclosure does not need a vent in advance. Enclosure vent area should always be measured and a test completed to ensure adequate relief-venting.
The last thing needed, should a fire event occur, would be to make a bad situation worse by damaging the enclosure.

Common relief vent design problems include:

a. sized too small
b. only opens partially
c. won't open at all
d. will not open fail-safe in case of power being cut to motorized dampers
e. blocked along the venting ductwork or at the exit flap
f. non-existent
g. installed backwards

h. exhausting to an area that is tight enough to cause damage outside the enclosure

OPEN VENTS AS EARLY AS POSSIBLE

The sooner vents open once the enclosure goes positive, the lower the peak pressure that will be produced. Waiting until the maximum allowable peak pressure is reached before the vent opens will not allow any time for the pressure to bleed off resulting in a higher peak pressure. It is suggested to open the vent early, at 50 Pa, which is about one pound per square foot. Flow at 50 Pa is already substantial. The square root relationship means that flow at 50 Pa is already half of what it will be when the pressure reaches 200 Pa!

VENT AS HIGH AS POSSIBLE

Ideally relief dampers would be located above suspended ceilings so that air is vented and not agent. Beware of lay-in ceiling tiles that will be easily blown out as the agent makes its way to the relief vent or leaks above the ceiling.

TYPES OF RELIEF DAMPERS TO SPECIFY

The safest installation is one where only gravity holds back the relief damper. Where venting is required in both directions, it may be necessary to install two separate dampers unless a double acting damper can be found.

If electronic and pneumatic actuators are used, they must be fast enough to open before the pressure rises much above 50 Pa and must be tested with a door-fan upon installation and at least annually to ensure they operate as designed.

All dampers should be operable with the door-fan supplying a 50 Pa test pressure and the actual vent area of the entire venting path measured. All dampers must be checked to ensure they open as specified since past experience shows that factory damper calibration is incredibly unreliable.

PAY ATTENTION TO WHERE THE VENT DISCHARGES

Venting to the outdoors can be costly and often impossible. Elevator shafts and stairwells may be restricted since they are both egress routes. Venting into large volumes versus the outdoors may seem like a good way to get rid of a lot of vented gas but if that enclosure is not itself vented to outdoors then large pressures can still build up.

DETERMINING VVR VALUES FOR PREDICTING PEAK PRESSURE

A test program is currently underway at Fike's USA test facility where all agent manufacturers have been invited to submit samples of their agents so that they can be tested and compared under the same controlled test conditions to provide consistent results. A technical committee has been convened under the chair of Mark Robin to collect this data. I am currently involved with guiding the testing process.

One goal is to produce a unified set of data that can be correlated across agents of various concentrations, at various humidities, and across other agent properties. Numerous discharge tests have been performed in the past, but the measurement methods and data recorded have varied so much that it has been difficult to make good comparisons. Leakage measurements for example were not taken at pressures similar to those where the venting is expected to take place; nor were they done separately in both directions.

This testing program will standardize this data collection so that the parameters needed to predict the peak pressures (and hence the required vent area) are clearly understood.

Our initial analysis of many tests in a small tank-like enclosure at Fike indicates the key parameters are as represented in the abbreviated Table 6. Full scale testing will follow in a 103 m^3 enclosure where, in addition to separate vent area measurements for venting and leakage area measurements for retention purposes, the leakage distribution will be measured to attempt to correlate actual retention time with the NFPA Annex C Enclosure Integrity Test Procedure.

Table 6. Required Data for Determining Peak Pressure Characteristics.

Clean Agent	**HFC-227ea**	
Volume	**0.422**	m^3
Wall construction	**Steel tank**	
Vent Area of enclosure, ELA at - 60 Pa	**1.20**	cm^2
Vent Area of enclosure, ELA at +60 Pa	**1.20**	cm^2
Discharge Time to achieve design %	**5.45**	sec
Restrictor Nozzle size	**1.27**	mm
Peak Nozzle pressure	**1266**	kPa
Weight of agent used, kg	**0.189**	kg
Elevation above Sea Level	**50**	m
Agent design concentration by NFPA calculation	**5.79**	%
Initial temperature of agent in tank	**21**	C
Fill density, volume of bottle is 300cc	**641**	kg/m^3
Cylinder pressure	**2480**	kPa
Valve opening characteristic (fully or gradual)	**Fully**	Fully or Gradual
Humidity in chamber prior to discharge	**49.2**	%
Predicted Agent flow rate	**2.1**	kg/min.
Observed: Negative Peak Pressure	**387**	-Pa
Observed: Positive Peak Pressure	**671**	Pa
Observed: Temperature at start of discharge	**21**	C
Observed: Minimum temp at end of discharge	**7**	C

Data for halocarbons suggest a complex relationship between VVR and peak pressure. Extrapolating from measured peak pressures to standardized peak pressure values of interest, such as 250 and 500 Pa may be difficult. Therefore, it is recommended that tabulated values be determined experimentally and prediction models be used to interpolate and extrapolate to values of interest. Preferably, many tables of results similar to Table 6 will be created to establish a clear picture of the worst-case conditions to ensure the recommendations are fail-safe

Table 7. Essential Results from HFC 227ea Discharge Test in Figure 1.

Clean Agent	HFC-227ea	
Volume	**0.422**	m^3
Wall construction	**Steel tank**	
Vent Area of enclosure, ELA at - 60 Pa	**1.20**	cm^2
Vent Area of enclosure, ELA at +60 Pa	**1.20**	cm^2
Discharge Time to achieve design %	**5.45**	sec
Agent design concentration by NFPA calculation	**5.79**	%
Valve opening characteristic (fully or gradual)	**fully**	
Humidity in chamber prior to discharge	**49.2**	%
Negative Peak Pressure	**-387**	Pa
Positive Peak Pressure	**671**	Pa
VVR for -387 Pa and +671Pa =	**2.8**	**cm^2/m^3**

Inert agents, in contrast to the halocarbons, follow a path that is somewhat easier to model since there is no change of phase; meaning there is no significant negative peak pressure pulse. Typically the peak pressure created by the inert agent is fairly predictable so fewer test points will be required. Humidity does not seem to be a factor for inert agents.

KEY PARAMETERS AFFECTING PEAK PRESSURE

Temperature: Discharge into hot fires can produce double or more pressure but for the purposes of the venting analysis, only cold discharges are considered since it is assumed that the fire will be put out before significant heat is produced by a live fire.

Wall construction: Going from cinder block to more flexible wallboard will reduce the pressure pulse by about 10% to 40% requiring less vent area. Separate VVR values could be quoted of different wall combinations.

Total Vent Area is the sum of all the intentional and unintentional openings and dampers that will be open when the discharge occurs. The vent area that the discharge will see is the prime determinant of peak pressure.

Discharge Time for halocarbons is the time to discharge the liquid portion of the agent and for inerts it is the time to achieve 90% of the design concentration.

Agent design concentration is the value calculated using the NFPA formula based on the weight of agent in the tanks. The actual concentration may be larger since the NFPA formula assumes some agent losses that may not occur.

Valve opening characteristic indicates where it opens fully or gradually to “soften” the discharge. Most valves open completely upon actuation but some types open gradually to lessen the initial peak pressure.

Humidity: Humidity has the effect of increasing the negative peak over a range of low humidities for halocarbons but would not have much influence with inert agents. It could be as much as +/- 40%.

OBSERVATIONS AND CONCLUSIONS

Signs to watch for that will increase peak pressures:

1. Reliance on without a verification program to ensure they will open.
2. Retention times over 20 minutes for 50/50 leakage distribution indicates there is half the leakage when compared to 10 minutes making the peak pressures as much as four times greater.
3. High enclosures with high minimum protected heights need to be tighter to hold agent
4. Minimum protected heights over 80% of room height cause the enclosure to be tighter
5. High concentrations
6. Rapid discharges

Whether to recommend peak pressures of say 1000 Pa in addition to the most commonly discussed 250 and 500 Pa should be considered since specifying these pressures too low may force unnecessary vents to be installed.

The concept of there being a solution space between the conflicting demands fewer leaks for retention time and more leaks for venting of peak pressures should be properly understood by both the designer and installer to minimize problems and maximize a system's potential.

Systems must be field checked to ensure sufficient vent area is in place. Operable vents must be tested annually in simulated conditions to ensure they will function properly and to ensure that the ducting leading away from them is not blocked. The cost is minimal and the benefits are huge.