Head Office
Sales and Support
1639 West 2nd Avenue, Unit #330
Vancouver, BC Canada V6J 1H3
P: 604.732.0142 **F:** 604.737.0162
E: sales@retrotec.com

retrotec
airflow systems since 1980 www.retrotec.com

Warehouse
1060 East Pole Road
Everson, WA 98247
P: 360.738.9835
F: 364.647.7724

TESTING ENCLOSURES: OVERVIEW OF A DOOR FAN TEST

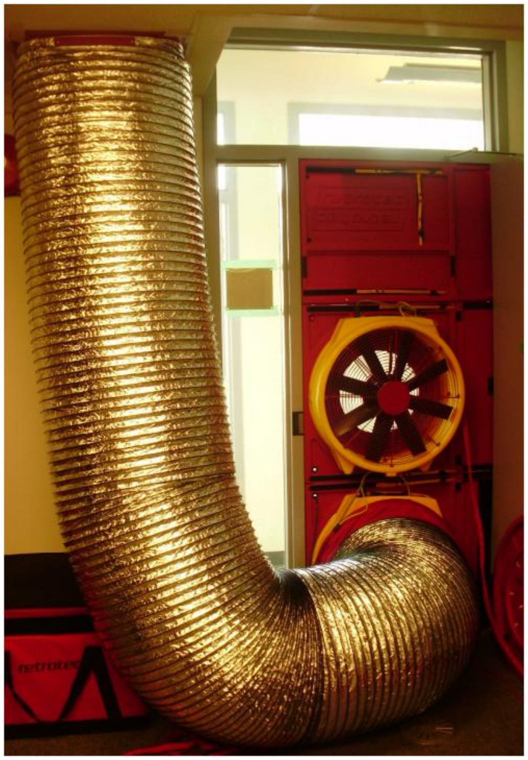
The Enclosure Integrity Test's primary goal is to predict the enclosure's retention time in the event that the Clean Agent Fire Suppression System is discharged. This is accomplished by performing a Door-Fan test.

DOOR FAN ENSURES PASSAGE OF DISCHARGE TESTS

Prior to 1989 several progressive installers found a unique way to ensure that they would always pass the discharge test. They used a fan mounted in a doorway to create a pressure which allowed them to locate hidden leaks using chemical smoke. When the leaks were sealed, the room would always pass the discharge test. It worked so well that the discharge test has now been replaced by the door fan test.

DOOR FAN REPLACES THE DISCHARGE TEST

Now, the NFPA 2001, NFPA 12A, ISO 14520 and EN 15004 recognize an enclosure integrity test as part of the acceptance procedure for all clean agent systems. This includes halocarbon and inert agents. The comprehensive test and calculation procedure predicts how long the agent would stay in the room if it were ever discharged.



In the past, enclosures were often designed merely to pass the discharge test. This often left rooms with fire barriers on only 5 sides with the top completely open — often only ceiling tiles stood between the protected enclosure and an adjacent unprotected area. Smoke or fire could readily enter from above. The discharge test only verified agent distribution in one location, usually the most favorable. This may have led to assuming that other approval steps could be overlooked. To make matters worse, the discharge test was never repeated. The room leakage would increase steadily, compromising the system from day one.

Now, the EPA, IRI, FM, other insurers, fire suppression equipment manufacturers, and the FSSA all encourage door fan tests on every installation. Door Fan tests should be repeated annually or whenever extra holes are made in the enclosure.

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WHAT IS A DOOR FAN TEST?

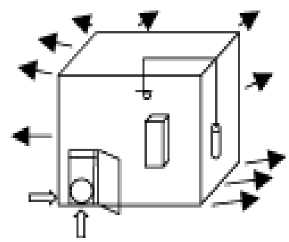
The door fan itself merely measures the size of holes in the enclosure and the pressures that may exist across them. Computer software does the rest of the simulation and comes up with the prediction. The software walks the user through all the steps in a controlled way to ensure each step is done in accordance with the chosen standard.

MEASURING STATIC PRESSURES

In some cases damper or duct leakage cause a static pressure in the room. This static pressure pushes the agent out faster and is taken into account in the calculations.

MEASURING TOTAL ROOM LEAKAGE

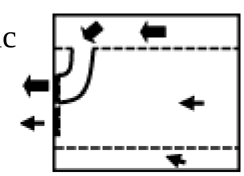
The door fan is temporarily installed in a doorway leading from the protected space (or test room) to a large open area or outdoors. The fan speed is adjusted to obtain a pressure between the test room and the volume surrounding the test room. This pressure (usually 10 to 15 Pa or 0.04" to 0.06" w.c.) is similar to the steady state pressure (column pressure) exerted by the agent at floor level at the start of the retention period. The computer converts flow and pressure readings into an Equivalent Leakage Area (ELA), or the total area of all the cracks, gaps, and holes in the test room.



The measurement is done by first blowing air out of the room (depressurization) and then into the room (pressurization). The two readings are averaged to reduce errors due to HVAC operation, wind and faulty gauge zeroing. One-way leaks are almost never a factor.

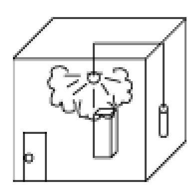
MEASURING LOWER LEAKS

Below ceiling leaks can be measured separately using a flex duct or plastic on the ceiling to neutralize ceiling leaks. These techniques eliminate the upper leaks for the purpose of measuring the more important lower leak. Both leaks are then used to make a more accurate prediction.



PREDICTING THE RETENTION TIME

Upon discharge, the agent mixes violently resulting in a homogeneous mixture. Pressures created in the first few seconds of discharge (referred to as dynamic discharge pressure) are ignored in the retention time prediction model because they are so short and because large factors for loss are already allowed for in the concentration formula.



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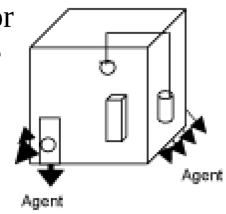
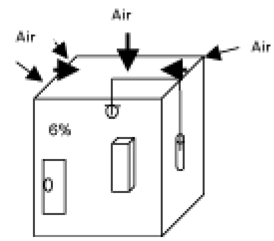
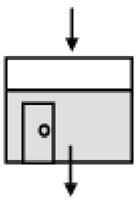


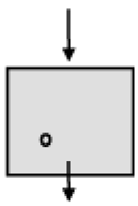
After discharge, the heavier-than-air agent pressing down upon the floor creates a small positive pressure. Flow develops whenever holes have pressure across them. The greater the pressure and the larger the hole, the greater the agent lost. As the agent runs out the bottom, a small negative pressure develops at the top. This pulls air in through the higher level leaks. Each agent creates a slightly different pressure as indicated by the densities as shown in the standards.



If the room's air-moving equipment is off during the retention period, the agent will drain out-much like water out of a hole in a bucket. Air will then flow in through the upper leaks.



The intersection between the pool of agent below and clean air above is referred to as the agent/air interface. This is called the descending interface case. This interface drops, as agent is lost from the room through leaks in the floor and lower wall area. Air from outside the room replaces the lost agent by infiltrating through leaks in the upper half of the room.



If air-moving equipment is left on during the retention period, the infiltrating air will continually mix in with the agent. This is called the continual mixing case. The concentration at the floor will decay at the same rate as the concentration near the ceiling.

Door Fan Compared to Discharge Test Results

Differences between this prediction and actual retention times are mostly due to leak location. If say 200 sq. in. of holes are distributed 50/50 (100 in the ceiling and 100 in the floor), the prediction will be very close to an actual discharge test. Let's say the result is 10 minutes. But, if they're actually distributed 75/25, then the discharge test result would be 20 minutes but the prediction would still be 10 minutes because the first prediction always uses the worst case 50/50 distribution.

A second, more accurate prediction may be done if the below ceiling leaks can be measured or accurately estimated. There are three ways to do this. The distribution can be measured with a special flex duct apparatus or by taping over the ceiling to isolate the below ceiling leaks. It can also be estimated after a detailed inspection. The result is a longer retention time than the 50/50 assumption, although, typically the door fan test is much more conservative than an actual discharge.

This conservatism is an advantage because new clean agents have less tolerance for leakage than did the old Halon systems. Halon protected rooms could lose over 50% of agent concentration before the fire could re-ignite. The new agents are more critical and can normally only lose about 20% before re-ignition.

OPTIMIZE ROOM DESIGN…FOR SUFFICIENT RETENTION TIME

The computer predicts a time for the descending interface to reach the minimum protected height. Or, if there were continual mixing during the retention period, for the concentration to fall to the minimum that would prevent re-ignition after the hold time.

It is up to the specifying engineer to come up with a retention time that is both adequate and an enclosure design that can reasonably be built tight enough. Often the general contractor finds himself rebuilding a room that was not designed to be tight enough to hold agent.

In general there are 5 guidelines to follow that will ensure a properly compartmentalized hazard. These techniques can also be looked on as part of the passive fire protection designed into the enclosure.

First, run walls slab to slab. Include construction details that would allow for sealing of the wall to the upper slab.

Second, in enclosures where the walls do not go slab to slab, consider eliminating the use of t-bar suspended ceilings. Use a solid sheetrock ceiling with access hatches and facility to walk above it.

Third, maximize the room height and volume. Place the ceiling as high as possible. The greater volume of clean agent in the enclosure, the more reserve and the greater the protection.

Fourth, select an appropriate retention time for the specific enclosure. NFPA 2001 (2008 ed.) states "… the design concentration … shall be held at the highest level of combustibles for a minimum period of 10 minutes or for a period to allow for response by trained personnel..." Retrotec suggests the following guidelines as being the minimum leakage that can be obtained in small enclosures. In fact, the room size dictates the maximum retention time that can practically be achieved.

For example: a remote site where re-ignition was possible and where it would take 30 minutes for a responsible party to arrive, should be specified as 30 minutes. On the other hand, a small room with little or no potential for a deep-seated fire and where personnel would respond within 5 minutes would need a retention time of 5 minutes.

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The minimum leakage areas shown in the second row are more in keeping with how tight rooms can be made as they get smaller. For example each room regardless of size must have a door, and door usually leaks about 5 to 20 sq.in. depending on how well they are weather-stripped. Reducing the total leakage down to the 7 sq.in. that would be required to achieve a 10 minute hold time in a 350 cu. ft. room is not practical.

For room volumes of	*2500*	*1250*	*625*	*350*	cu. ft.
the minimum achievable leakage area:	62	42	32	23	sq.in.
Suggested retention time for inert agents:	10	10	8	6	minutes
Suggested retention time for halocarbons:	8	6	4	3	minutes

Fifth, if protection is required at the ceiling or in the upper 80% of the room, continual mixing of the agent during the retention time should be considered. In this case, start with the highest possible concentration and specify the minimum that it can fall to over the retention time. The gap between these two must be at least 20% to allow for leakage.

WITNESSING AN ENCLOSURE TEST…FOR AUTHORITIES HAVING JURISDICTION (AHJ)

KEY THINGS TO LOOK FOR ARE:

1. Re-measuring of the volume on site.
2. Witness the room and flow pressure readings.
3. Ensure the flow range on the printout matches the one used on the test per the manufactures range description.
4. Ask for a field calibration check for new operators.
5. Ensure the minimum protected height as measured from the lower slab is at least equal to the highest equipment being protected.
6. Or, for continual mixing, the minimum concentration must be sufficient to prevent re-ignition.
7. Static pressure that will exist at agent discharge; particularly floor voids that will be under pressure during the agent retention period.

COMMONLY NEEDED CLARIFICATIONS

All Inert agents are heavier than air as indicated in NFPA 2001 and will run out due to room leaks. Inert agents are not as heavy as halocarbon mixtures and usually only run out at about half the rate.

Unlike the discharge test, a minimum concentration cannot be specified. The new test uses the conservative assumption that once the concentration starts to drop that protection is immediately lost. The rare exception is where mechanical mixing has been designed to run throughout the retention period. Here a minimum concentration must be specified.

Covering ceiling level leaks to measure leaks in the lower part of the room is not the same as taping up leaks to pass a discharge test. The leakage of the ceiling has already been measured in the previous test and now the lower leaks can be measured separately to get a more accurate prediction. The operator must enter the whole room leakage and the below ceiling leaks separately in the software.

Rooms must be tested positively and negatively to eliminate bias due to duct leaks not because of positive pressures after discharge.

Additional Uses

Checking relief-venting areas. A door fan is commonly used in conjunction with software to assess peak pressure in the event of agent discharge and to suggest free vent area (FVA). In some cases the door fan may show that no additional venting is required or conversely that the installed venting is insufficient.

Smoke control in mult-floor buildings could also be predicted. Smoke flow calculations usually use a guess for the leakage between components. The door fan equipment developed to replace the discharge test could establish a measurable level of safety here as well.