Integrity Testing / Sealing

The ability of a suppression system to operate within the design parameters is strictly governed by the ability of an enclosure to retain / contain the extinguishing agent. If an enclosure is unable to do this it will not be able to effectively retain the extinguishant and therefore will not be able to operate as intended.

In many cases the extent of protection will depend on the materials or segregation applied to an enclosure. Sometimes ceiling voids due to the large expanse above are not always protected, if this is the case then the only barrier that remains between the area and the void above that isn't protected is the suspended ceiling. To achieve an acceptable integrity test result this will need to be sealed as far as is practically possible to enable the risk area below to contain the extinguishant.

If practically possible ceiling voids should be protected as the added volume and increased allowable leakage will assist in enabling an enclosure to satisfy an Integrity Test.

Floor voids are very commonly included in an enclosure, to allow the running of often hidden cables etc. This invariably means that penetrations are cut through the suspended floor to allow these services to pass into the equipment above. When this occurs it is important to ensure that this section is adequately protected by the suppression system.

When an enclosure is supplied with a suspended floor invariably it **has** to be included within the protected volume as extinguishing agent will usually seep into this. If the floor void isn't to be protected then the entire floor area needs to be adequately sealed off and segregated from the rest of the enclosure and due to the hazard of fire entering up through the floor void it should be fire rated to prevent this possibility occurring, this is very unusual.

Any penetrations within should be effectively sealed around the enclosures perimeter and it is advised that the BSRIA recommendations are followed, in addition to this we have noted that as a minimum the following leakage areas apply as they are common leakage points.

The walls in all areas should be effectively caulked to the solid floor slab (and ceiling slab) around the entire enclosure perimeter.

As always, all services that pass through any of the enclosure barriers will need to be effectively sealed. It is important to note that the use of the correct sealing materials is essential.

The installation of re-sealable openings around cable inlets, is recommended, with extra capacity installed to handle expected future expansion (if proposed). All holes, cracks, or penetrations leading into or out of the protected area will need to be sealed.

Pipe chases and cable trays need to be sealed around the inside at a point where they pass through the envelope of the protected zone. Porous block walls need to be sealed slab-to-slab to prevent gas from passing through the block, if there is any doubt then it is recommended that the block wall be painted from slab to slab.

All ducts leading into or out of the space must be mechanically dampened. All unused and out-of-service ductwork leading into or from a protected area shall be permanently sealed off (air tight) at the point where they breach the envelope of the protected zone.

All doors shall have door sweeps or drop seals on the bottoms, weather stripping around the jambs, latching mechanisms and door closer hardware.

This is compounded when it is considered that the enclosure is small in volume, this is due to the fact that small volumes will have a large surface area by comparison.

Ideally a test should be conducted first to establish what the leakage factors are. Without this there is absolutely no guarantee that an acceptable result will (or could be achieved)

It is very important to note that when an enclosure has to be sealed, the use of the correct sealing materials is an essential element; rockwool is porous, tape (sticky back or otherwise) is not classed as permanent and often peels away within 12 months, for this reason it should not be used as a finished seal, when using foam it is usually very difficult to obtain an effective seal as air pockets tend to occur in corners etc and once this has happened it is very difficult to remedy, the other important factor to note is that there are only a few types of foam on the market that are non-flammable.

One other consideration to be borne in mind when using foam is that it is difficult to obtain a neat finish and its use often results in an unsightly mass, we tend to steer clear of using foam unless as a back filler, due to these particular problems.

Appendix B of the 1996 NFPA 2001 standard for the fire protection industry specifically addresses issues that impact on Enclosure Integrity Testing. Historically, the vast majority of discharge test failures have been caused by lack of enclosure integrity. The proper initial concentration is achieved, but the enclosure doesn't retain the agent. The NFPA Enclosure Integrity Test is an alternative means of verifying adequate enclosure integrity for total flooding systems universally recognizing enclosure leakage as a major cause for system failures.

The Enclosure Integrity Test on its own is not a complete replacement for the discharge test. Other aspects of the system installation must also be approved.

1) Greater overall fire protection of the hazard will be obtained through having at least a one-hour fire rated separation surrounding the enclosure. Compartmentation is considered one of the key first elements in effective fire protection.

2) Greater environmental control (humidity, dust and temperature) and lower ongoing maintenance costs will be provided by a tight enclosure.

3) Greater protection from smoke contamination originating outside the hazard is obtained with a tight enclosure.

4) The increased cost of providing additional drywall and dampers will be offset by lower maintenance costs, possibly lower initial acceptance test costs if a discharge test is not performed and also reduced costs to maintain an acceptably tight enclosure over time.

5) Authorities Having Jurisdiction now require periodic Enclosure Integrity Testing to ensure continued performance. Slab to slab walls make the enclosure easier to "re-accept" in the future.

Penetration Planning

Achieving and maintaining a high degree of tightness is facilitated by having the location and design of certain penetrations, specifically for cables, planned in advance. The installation of re-sealable openings is recommended along with sufficient extra capacity installed to handle expected future expansion.

Sealing openings between cables within bundles is a very common and difficult problem to solve once all

cables are in place, as small gaps often remain where cable bundles exist.

HVAC Dampers

All ducts leading into or out of the space must be mechanically dampered, even if the air handler serving them will be shut down and the ducts terminate at ceiling level. Dampers should be smoke rated to provide the most effective method of operation and these should be checked regularly.

Minimum Protected Height

Even if a Clean Agent protected enclosure is designed and built to be as tight as possible, a certain degree of leakage must be expected to occur.

The leakage mechanism is somewhat as follows:

During the retention period, the agent/air mixture, being marginally heavier than air, will generally leak out of lower openings. Air will enter through openings around the enclosure (generally at higher levels) at the same rate to replace it. If air-moving devices in the room are shut down, this incoming air tends to collect at the top of the room. The Clean Agent mixture descends over time and this layer between the original agent/air mixture and the infiltrated air is known as the descending interface.

However, if any air moving equipment is left on during the retention period (Fans, air conditioning units, and UPS equipment), the incoming air becomes mixed with the original agent/air mixture. This causes the average concentration throughout the room to decay. This phenomenon is known as mechanical mixing and has a completely different set of test parameters (please call if unsure).

If a descending interface is formed, the allowable height to which it can descend in l0 minutes is a **crucial** factor.

This minimum protected height is usually where the upper probe would have been placed during a discharge acceptance test (**tallest equipment cabinets**, **usually consisting of essential equipment**), this is best defined as: the highest combustible item in the enclosure.
In the case of protected areas it is important to design the room and its equipment (cable trays are one of the most common problems) so that all combustibles are kept below the 75% level (measured from the floor slab). The 75% level is an NFPA guideline, and allows for a reasonable amount of Agent leakage (up to 25% of the room volume) whilst not severely restricting the equipment design.

Small rooms (up to approximately 200 cubic metres) have historically been the most difficult to pass using a discharge test. There appears to be two reasons for this. One is that Clean Agent is more likely to be lost during the initial discharge, especially if there is an unprotected ceiling void above. This appears to be reduced if a "soft" discharge is used (prolonged affect).

If the enclosures are smaller yet again the problem does get even more difficult to resolve often resulting in an enclosure that can not obtain a straight pass via the Integrity Test.

The predominant reason appears to be because small rooms have much less favorable surface to volume ratios. For example, a 400 m^3 room has ten times the volume of a 40 m^3 room, but has only three times the wall area. Relatively speaking, the small room has to be much “tighter” to retain the agent. As the Room Integrity Test is even more stringent than the discharge test, this can make small rooms difficult to accept if they aren't practically airtight, in some cases this is not feasible.

This phenomenon is enhanced when you increase the number of possible fixed leakage factors. For example

there will always be a certain amount of leakage around a door to allow it to be opened and closed, so if you have a large number of doors there will almost certainly be a larger amount of natural leakage. If this is applied to a very small enclosure it is going to be very difficult, if not impossible for it to obtain a straightforward pass result (this is generally for enclosures that are 20 cubic metres or less).

If all air moving equipment will be shut down in the event of a fire, the Minimum Protected Height (e.g. 75% of room height) and Minimum Initial Concentration should be specified in the bid request documents. It is recommended that the Minimum Protected Height be no higher than 75% of the room height, especially if the enclosure volume is less than 200 m^3.

Enclosure Integrity Specifications

On new installations, it is Generally the Main Contractor if one is present, who is responsible for the overall enclosure Integrity / tightness. The Contractor in turn would then require that all his sub-contractors perform the necessary sealing, which relates to their work. Any work being done on the installation by second level contractors (e.g. cable installers) not operating under the Main Contractor must also be subjected to this requirement under their contracts.

If the Clean Agent system is being installed as a retrofit, or in an existing building it is down to the landlord or building owner to be responsible to ensure that the enclosure is adequately sealed. It would be unreasonable to expect anyone else to be responsible for a building that may already be leaking. Obviously if an enclosure has been examined and a cost has been put forward to cover remedial sealing works then this statement will not apply.

If an Integrity Test has been conducted then the results should be made known to all parties so the remedial works required can be adequately catered for.

At the onset it is normally common practice to put forward one contractor who must be made responsible for sealing existing holes. If no building contractor is involved in the retrofit, the Clean Agent installer may be able to arrange for this service. The prescriptive specifications give guidance on what must be sealed, while the performance specification determines whether the job was done right.

In order to pass the Enclosure Integrity Test, the contractor may have to seal items, which are not specifically described, in the prescriptive specifications. The list below covers most possibilities.

Enclosure Integrity Performance Specification

Enclosure leakage shall be eliminated to at least the degree necessary to enable the Clean Agent protected enclosure to pass a test conducted in accordance with the 1996 NFPA 2001 Enclosure Integrity Procedure**.** It is possible to calculate in advance using NFPA 2001 Appendix B what the maximum allowable Equivalent Leakage Area would be for the enclosure. If this is done the performance specification could be even more specific.

Enclosure Integrity Prescriptive Specifications

The following items cover enclosure leakage in a general fashion, and should be placed in the General Contractor's specification and appropriate to specific subcontractors in their specifications. If the client or AHJ requires that the materials and techniques used must produce a one or two-hour fire rated enclosure, this must be specified.

Because historically the walls and roof of unprotected ceiling voids above suspended ceilings have not had to be well sealed to retain agent, existing building practice, if retained, will produce enclosures where large

leakage areas will be measured, resulting in unacceptably low predicted retention times. It is recommended that where possible the walls and roofs of unprotected ceiling voids be sealed as tightly as the protected enclosure below. It is recommended that every attempt be made to seal the ceiling void first. However if it is fairly evident that the leakage occurs evenly throughout the area even to the degree that it is possible that a greater percentage occurs at low-level the BCLA method should NOT be utilised.

General / Standard Sealing Requirements

The perimeter walls of the protected enclosure shall extend from the structural floor to the structural floor above, or the roof / solid slab ceiling level. Alternately: The (suspended) ceiling of the enclosure shall be of a solid plasterboard construction, taped and painted. Access panels may be required if access is essential.

Where an under floor space continues out of the Clean Agent protected area into adjoining rooms, airtight fire rated partitions shall be installed under the floor directly under above-floor border partitions. These partitions shall be caulked top and bottom. If a removable floor tile extends under a doorway over such a partition, it shall either be: permanently sealed in place; installed with a flexible seal between it and the wall below; or the tile shall be discontinued at the doorway with a permanent airtight ledge created up to which the floor tiles abut. If adjoining rooms share the same under floor air handlers, then the partitions shall have dampers installed of the same type as required for ductwork.

All holes, cracks, or penetrations leading into or out of the protected area shall be sealed. Pipe chases and cable trays shall be sealed around both the outside and inside at a point where they pass through the envelope of the protected zone.

All walls shall be caulked around the inside perimeter of the room where the walls rest on the floor slab and where the walls intersect the ceiling slab or roof above.

Porous block walls shall be sealed slab-to-slab to prevent gas from passing through the block. Multiple coats of paint may be required. It should be noted that it is usually very difficult to determine if a block wall is porous this can only eventually be confirmed once all other leakage areas have been resolved.

If there is any doubt then it is recommended that the block wall be painted from slab to slab.

All doors need to have door sweeps or drop seals on the bottoms, weather stripping around the jambs, latching mechanisms and door closer hardware. In addition, double doors shall have a weather-stripped astral to prevent leakage between doors and a co-ordinator to assure proper sequence of closure.

Windows need to have solid weather-stripping around all joints. Glass to frame and frame to wall joins shall be sealed.

All floor drains need to have traps designed to have water or other compatible liquid in them at all times.

All unused and out-of-service ductwork leading into or from a protected area needs to be permanently sealed off (air tight) with metal plates caulked and screwed in place at the point where they breach the envelope of the protected zone.

All ceiling tiles shall suitably weighted.
The possibility of ceiling tiles being displaced during a discharge should be addressed at the design stage. Possible options include tile clipping, nozzle deflectors, lowering the nozzles a certain distance from the ceiling and ensuring proper nozzle location. Contact Clean Agent equipment manufacturers for guidance.

Clean Agent System Specifications

This section covers only the issue relating to the Clean Agent system design, which has an impact on the Enclosure Integrity Test. A complete specification should cover the appropriate 1996 NFPA 2001 articles and features of particular interest to the client.

The system shall be designed and installed to provide an adequate concentration throughout the protected enclosure upon discharge, as calculated in NFPA 2001 or the relevant design documents. The protected enclosure extends from the floor slab to (the slab above the suspended ceiling).

HVAC Specifications

Ductwork in service with the building air handling unit shall have gasketed low leak agent/smoke type dampers with flexible seals (option: conforming to UL-555S "Standard for Leakage Rated Dampers For Use in Smoke Control Systems", Class I leakage rated). Dampers shall be spring-loaded or motor-operated to provide near airtight shut-off. (Option: The dampers shall be of the spring close, motor open type.)

The dampers shall be installed as close as possible to the duct's point of entry into the room. All duct joints between the damper and the duct entry point shall be sealed. The gap between the damper frame and the duct wall shall be sealed. A minimum 6" square access panel shall be installed to permit internal inspection of the damper.

It is recommended that whenever possible, any in-room air conditioning units be shut down upon discharge to reduce the possibility that they will expel the mixture from the sub-floor.

Ideally, the Clean Agent protected enclosure will be a "dead" room from a static pressure standpoint by the time the Clean Agent discharges. If the dampers are truly tight, and the in-room air conditioning units are shut down, close to zero pressure is usually achieved. Occasionally, however, significant imbalances exist in the building HVAC system, which could increase the leakage of Clean Agent from the enclosure. If a significant static pressure is uncovered during the Enclosure Integrity Test which is not solved by improving damper seals or sealing leaks, it may prove to be necessary to have that zone of the building's air handlers shut down in addition to closing the dampers.

Approval/Acceptance of Clean Agent Suppression Systems

The following article covers **only** the acceptance of the Clean Agent system, which is the Clean Agent installer's responsibility.

Historically, the vast majority of discharge test failures have been caused by lack of enclosure integrity.

The contractor shall provide a test report, after the tests are completed and the system has been accepted, the system shall be brought to full operating condition. It is important to note that while the Clean Agent contractor is often responsible for providing the Enclosure Integrity Test, he is not responsible for the sealing unless **specifically** stated in his contract. If it is determined at the early stages of a contract that it is going to be difficult to seal an enclosure the type of agent to be utilised should be carefully examined. Different agents will leak out at differing rates, depending on their molecular weight and the concentration utilised.