Commercial buildings have existing dampers that can easily be re-configured to assist in mitigating the affects of a chemical, biological, or radiological (CBR) attack.

When analyzing security procedures for an airborne chemical, biological, or radiological (CBR) attack, there are many tactics an engineer can incorporate into a building’s existing damper system to help protect building occupants.

The simpler a system, the better an operator who is not an expert at it can understand, maintain, test, and use it to the best of its capabilities. Commissioning, documentation, maintenance manuals, instructions, and training are critical.

Almost every building’s duct and damper arrangements are unique. In all cases there are principles taken from fire and smoke control that guide any design approach regardless of the type of system. Familiarity with smoke management practices allows the mechanical designer to avoid reinventing the needed tactics.

The engineer must individually consider potential attack points – external, air handling intake, internal, multiple – and consider the options for action. Before using the damper system, he or she must thoroughly understand the entire building. Information from sensors and indicator lights, DDC system displays, and manual and automatic alarms must be readily available to operators. The designer must consider all these factors in order to facilitate the system’s use by staff, fire fighters, or police.

**STRATEGY**

The basic operation of the air handling units and the fire and smoke system will dictate how they might be used in an emergency situation. While more could be done in all of the following instances, here are some basics:

- Limit transmission of internal release. Isolate any contaminant by isolating the area or floor of the building with smoke or isolation dampers.
- Limit injection of externally released agents by...
shutting down air handlers and closing economizer dampers in potentially affected areas.

- Pressurize spaces adjoining an area where contaminants are known to be present. This helps prevent movement from a contaminated to an uncontaminated area. The smoke control zones provide an ideal map; sandwich pressurization systems provide a tool. Where smoke control systems are not installed, floor isolation is the minimum prudent requirement.
- Exhaust any possible contaminants outside. Be aware of downwind intakes or the possibility of spreading to other local areas to avoid exposing other people. Codes require careful placement of exhaust and intake louvers, but older buildings may not comply and as of this writing, location of smoke exhaust fan outlets are not covered by codes.
- Prevent intake of contaminants if they are externally present. Shut down all fan systems as a default procedure. The fire fighters’ control station should be in a protected room with its own air handler and ideally, separate CBR filtration. Remote modem control by the DDC system is an option.

The general layouts shown in Figures 1 and 2 show the complexity of some situations. Note that the Figure 2 distribution pretzel is no exaggeration and duct paths are typically hidden in a structure and/or above ceiling tiles. Frequently, drawings are either absent or inapplicable, making retrofits difficult to design properly. Typically, trade-offs will be needed to deal with cost versus benefits versus possibility of attack.

PRIORITIES

The following goals may be incorporated into a smoke control and HVAC design:
- Have a written list of priorities, action items, and options prepared for building operators.
- Sense, alarm, and notify as
necessary. Instructions over the PA system must be loud and clear; panic must be averted.

- Ensure that maintenance personnel, BAS or security system contractors, building security, police officers, or fire fighters can access the control systems and that they have a copy of the written list of priorities.
- Reduce exposure of occupants in any area of a building where toxic agents have been introduced.
- Minimize exposure of other occupants by stopping spread through building.
- Avoid exposure of emergency personnel.
- Avoid spread to other buildings or outside areas where people are present.
- Minimize contamination of the overall building.

These goals will usually be impossible to achieve simultaneously. For example, reducing exposure in part of the building may best be accomplished by ventilating and exhausting the space. If the exhaust spreads toxic agents downwind, the agents may become entrained at the intake louver of another building. This conflict may be unavoidable. Notifying and communicating with building operators is essential. Note that the most important factor is to protect occupants. The building itself is of secondary importance.

**DESIGN CONSIDERATIONS**

Before applying any strategy for damper control, the mechanical engineer must thoroughly examine the building requirements. This involves studying information garnered from standards, codes, the owner, and architect. Above all, the engineer must determine if his or her vision is physically possible or what changes might be needed to achieve it.

Code officials must become knowledgeable about the exceptions to existing codes that may be necessary to achieve overall design goals. There will be a transition time before codes are adapted to any changed circumstances.

The engineer needs to study information including the building components, zones and airflow paths, normal movement of people and materials into and out of the structure, occupancy levels, lobbies, elevators, parking garages, windows, doors, and exiting routes.

Most smoke is hot and will rise, while most CBR agents are likely to be particulate or aerosols that move with standard ventilation air. Gas tracer tests will help determine what design tactics need to be employed. Smoke generators produce cold chemical smoke, which is appropriate for simulating chemical airflows.

Hazard analysis includes wind, make-up air, short-circuiting of airflow from supply to return diffusers within a building or from exhaust to intake louver outside the building, VAV fan involvement with pressure differences and in stairwells, mechanical exhaust, and the general complex airflows of any building.

Figure 3 depicts the airflows involved in a single-zone VAV system with a central return. Any strategy to contain transport of a contaminant in the space served while the fans continue to run will fail with the exception of areas immediately pulled negative by exhaust fans. Contamination of this space from others could easily occur due to pressure differences from other air handlers, piston action by the elevators, or stack effect.

**TACTICS**

Depending on the specific air handling systems, different tactics may be applied.
**Tactic: Shelter in Place**

All fans are shut down and the smoke control dampers are closed. This passive protection method is the default tactic in cases where it’s impossible to make informed decisions and where the CBR release has taken place outside of the building.

**Benefits:**

Existing switches on the fire fighters’ control panel can be employed. Cross training of police and fire fighters is possible; each can possess keys. Police are on patrol and are generally expected to be in a building sooner.

**Tactic: Zone Isolation**

The contaminated zone or zones are shut down while the other zones are left running. A default zone is a single floor. One zone or floor should be evacuated while the others are pressurized.

**Benefits:**

Not all fire-fighting stations have individual Hand-Off-Auto switches for each air handler. Retrofits using networked controls allow a relatively inexpensive method to gain control. Floor dampers are not required in most existing codes.

Where DDC has been installed, only slight modifications should be necessary to achieve goals. NOTE: Old pneumatically controlled buildings may need extensive modifications.

**Tactic: Zone Pressurization**

A contaminated area can be isolated by use of smoke control dampers. Air handlers may be shut down as necessary. Typically, only the contaminated zone is exhausted, and the adjacent zones are placed in full supply with exhausts closed.

**Benefits:**

Where full smoke control systems exist, this is the ideal method. The control panel lends itself to isolation without modification. Hand-Off-Auto switches already exist. Test switches allow for good maintenance checks.

**ENHANCED PASSIVE PROTECTION & OTHER APPROACHES**

In situations where the system is well understood, the system may be used in special operation modes. For example, a unit known to be far from any source of contaminant can be put into 100% outside air intake as a source of clean air. Intermediate units may be shut down or VAV box dampers in selected zones may be run full closed. Then, units near an externally released contaminant may be put in return air or relief fan only. This puts a positive pressure on both the outside air intake and exhaust air dampers to keep contaminants from entering.

Use of the DDC system requires knowledge of the operations and access codes. Police and fire fighters cannot make use of them without trained stationary engineers or building security personnel present. Training and operation procedures for

**Complexity of Airflows**

- **5-15% Duct leakage**
- **Mechanical exhaust**
- **Exfiltration**
- **Stack effect**
- **Elevator doors**
- **Other air handlers**
- **Combustion air infiltration**
- **Mechanical exhaust Exfiltration**

**FIGURE 3. The airflowes involved in a single-zone VAV system with a central return.**

**FIGURE 4. Floor isolation or smoke dampers at shaft penetrations in sandwich pressurization systems can be used for both smoke control and CBR isolation.**
each building may be easily established. The will to perform adequately must be important to management.

VAV zone dampers may be employed in zone isolation. Coordination between police or maintenance people physically on floors with the DDC control operator is possible. Given the missing drawings, deferred maintenance, tight facility budgets, and lack of will by management in many buildings, building codes will be necessary to enforce operational procedures. It may be more realistic to increase occupant awareness, which would put pressure on management to perform well. Prescriptive codes are not recommended; performance and flexibility are needed.

Police, firefighters, and building operators must think strategically before taking action. Reflexively shutting down all air handling units might cause more problems than allowing pressurization and exhaust to continue to clean the air. Placing systems in smoke mode may spread toxic agents if the improper mode is selected. Elevator doors may be open intentionally in smoke mode. Some fire procedures are inappropriate — such as recall of elevators to the ground floor.

An emergency official who has just entered the building for the first time would not know how to apply the the correct tactics.

** DAMPER CONSIDERATIONS
Class I AMCA licensed low leakage dampers should be installed on all change-outs in buildings and in new construction. The higher leakage Class II and III presently allowed in codes and standards are not appropriate and save very little money. Older class IV dampers leak excessively. (Leakage rated dampers are typically the fire and smoke combination dampers with UL555 and UL555S listing.) Economizer and floor isolation dampers need not necessarily be listed, but leakage rated dampers should be considered. The higher quality dampers can be used with standard modulating actuators.

Where an air handling unit is to be used for exhausting smoke or CBR contaminated air, the possibility of contamination of outside air via the recirculation air duct needs to be examined.

The relief fan system cannot cross contaminate the outside air. The return air system could contaminate the supply air. The outside air and relief fan or exhaust air dampers are of no concern.

Floor isolation or smoke dampers at shaft penetrations in sandwich pressurization systems can be used for both smoke control and CBR isolation (see Figure 4). (NOTE: Smoke control systems may not be effective on heavy chemical agents, which will tend to sink, unlike smoke.)

**CONTROL PANELS**
The design and style of the fire fighters' control station will vary, but it must be clearly marked and easy to use (see Figure 5 for an example). Anything more complicated would require study to achieve expert control.

A “kill switch” could be added to any panel to allow single switch shut down of all systems. The flexibility of the individual switches is preferred so that selective strategies could be applied.

Again, operators should have prepared plans for different eventualities. The probable operators of the system are not pressure control experts. Individual control of every final element can be expensive, particularly in large complex buildings (and if there is too much information, no one will be able to use it anyway). A trade-off between cost and potential benefits must be considered. Reasonable balance can be engineered into the system.

Most control systems have no indicator lights. In many, where lights are included, an entire zone or floor is indicated on one light. The proximity switches, auxiliary switches on the actua-

**FIGURE 5.** The design and style of the fire fighters' control station must be clearly marked and easy to use.
tors, or damper blade whisker switches are wired in series with the light.

As a monitoring system for zone smoke control, switches are cost effective and provide an effective maintenance and commissioning tool.

OTHER CONSIDERATIONS

While there are many details worth discussing that are beyond the scope of this article, here are some final thoughts.

The economizer sequence of operation and the damper control may be under fire alarm-isolated hard-contact relay control. In that case, the alarm panel must be able to operate dampers. The alarm company is rarely qualified to interface directly. The consultant’s drawings must indicate who is to provide what wiring at which terminal strip to separate trades or responsibilities.

If the economizer is under total control of the temperature control DDC system, then a clear sequence must be achievable via interface switches. If water coils can freeze, then the sequence in event of purge-evacuation must protect the coil by opening valves. (The design must consider every detail and provide 3-way valves and runaround pumps if necessary.)

System maintenance is a problem in most buildings. With budget constraints, operational checks are deferred until failure. Building owners, stationary engineers, and occupants must become knowledgeable about safety within the building and take responsibility. Instituting a training program or appointing a task force or review committee might be a good start.

While CBR threats exist, it is likely that fire is still a bigger threat to a building’s occupants. The smoke control system’s primary purpose is to allow people to escape in case of a fire. That goal should not be compromised by other security efforts.

CONCLUSION

Use of an existing smoke control system may allow for low-cost mitigation of the effects of a CBR attack. However, not every attack can be prevented, nor can control systems totally protect occupants. Placing isolation, economizer, and smoke control dampers under control of the fire fighters’ station may help protect occupants.

To more of a degree than in the past, the architect must design the building from the inside out. Airflow becomes a more important factor in building design and is not just the mechanical engineer’s responsibility.

Given ASHRAE energy and IAQ standards for design, the need for smoke and fire protection, and additional security issues, the mechanical systems in a building must be given high priority and a greater share of budgets.

At the same time we recognize the purpose of commercial buildings is to provide healthy, comfortable, productive environments, and engineers and architects must cooperate with one another to reach these goals.

FOOTNOTES


REFERENCES


ABOUT THE AUTHOR

Larry Felker is a mechanical engineer and fire and smoke product manager for Belimo Aircontrols (USA), Western Region, Sparks, Nev. He was formerly vice president of engineering for a Chicago controls distributor and technical manager for the western U.S. for Belimo. He also has experience in sales and training management.