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An Evaluation Procedure for Post-Fire Re-Occupancy in Commercial & Industrial Structures

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Introduction

Small-scale isolated fire events seldom occur in commercial and industrial structures (i.e., equipment failures, product combustion, electrical fires, etc. – Figure 1). However, when they do occur, these events can drastically disrupt production and create employee health concerns. Based on an actual flash fire/explosion event at an industrial building, this poster presents post-fire procedures an industrial hygiene (IH) professional can use to evaluate the indoor environment for potential hazardous conditions which could impact employee health, and outlines a methodology for re-occupancy.

Figure 1.
Example: Small-Scale Isolated Fire Event (Compressor)[1]

Evaluation Procedure

After a fire event occurs in a commercial or industrial building and first responders leave, management is left to deal with the aftermath. Depending on the level of impact to the building, management needs to make the decision to allow employees back into the building or to delay re-occupancy. The decision should be based on the best interests of employee safety and health. Re-occupancy is the most critical issue to address, as bringing production back online as soon as possible is often top priority. This poster presents **three key steps to evaluating post-fire events:**

1 Gather Information

2 Onsite Assessment
- Visual Inspection
- Initial Recommendations
- Sampling & Analysis

3 Re-Occupancy
- Isolation
- Remediation
- Clearance

Step 1 – Gather Information

The first step in response to a fire event is to gather good information. Information related to the event will set the stage for the subsequent steps of the evaluation. It is important to obtain information from reliable onsite personnel. This usually means someone with authority to make major decisions – i.e., upper management and who has means of obtaining information if it is not readily available. Answers to questions listed in Table 1 can be used as a guide for gathering pertinent information.

Table 1

Questions to Ask	
Question	**Relevancy**
Can you describe the event's current status?	Knowing the current state of the event shows the magnitude of the situation – event background, extent of damage, building accessibility, parties involved, occupancy status, active remediation, production status, known hazardous materials, ventilation status, potential structural impacts, photographs/video of event.
What kinds of materials were burned or impacted (damaged)?	Fire chemistry is very complex and produces many hazardous components. Post-fire investigations should focus on potential hazardous components of fire events which would be "left behind" and not necessarily those present during an active fire situation. Therefore, knowing the types of materials impacted is critical to anticipating potential hazards.
Are there reported employee injuries, health effects, or complaints?	Useful for understanding the degree, extent, and route of exposure. Identifies health sensitive population of employees (i.e., cardiac, respiratory, and immune compromised).
What are your immediate concerns and expectations of this evaluation?	Identifies the common goals between all parties (i.e., IH professionals, remediation contractor, insurance, site management, building owner, etc.). The complexity of fire-related chemistry, quantifying potential contamination, and remediation should be addressed during this conversation.

Step 2 – Onsite Assessment

In most cases, based on the initial information gathered, an onsite assessment is needed for an IH professional to formulate an opinion regarding re-occupancy of a structure associated with a small-scale fire event. Key steps to the onsite assessment process are presented in Figure 3.

Figure 3: Onsite Assessment Steps

1 Visual Inspection → **2 Initial Recommendations** → **3 Sampling & Analyses**

1. Visual Inspection

The onsite visual inspection of the fire event location is the most important step of the evaluation process. A thorough observation of all impacted areas (all areas visibly impacted by the event) should be well documented. Non-impacted areas of the facility should also be inspected for comparison purposes. Description of the extent of visual damage (i.e., fire-related particulates, water, physical/structural), the type of building materials affected, type of fire extinguishing agent employed, and current isolation and remediation efforts are critical pieces of information to be recorded. Although subjective, the presence, degree, and extent of fire-related odors should be well documented. In addition, a visual inspection of associated ventilation systems (i.e., inside air handling units, filters) is needed. Also, the presence and location of known hazardous building materials (i.e., asbestos, lead, PCBs, other materials) should be discussed with onsite management.

2. Initial Recommendations

Once a thorough visual inspection has been conducted, the IH professional can begin to make initial recommendations regarding limited re-occupancy, isolating the heavily impacted areas, personal protective equipment (PPE) for remediation contractors and other visitors, and re-occupancy of isolated areas of the facility (i.e., office areas). For example, if a fire-event occurs in a compressor room located in a production area of the facility, general office areas under separate ventilation would likely be able to be opened for work to resume if they were not affected by the event.

3. Sampling & Analyses

Based on the initial information gathered and the visual inspection, the IH professional can develop a sampling plan for the purposes of measuring the potential degree of exposure, extent of contamination, and/or detection/presence of combustion-related components or other hazardous materials. It is important to consider that sampling and analyses may not be needed in many cases due to the scale or location of the event. The IH professional needs to educate all parties on the purpose and limitations of any planned sampling and analyses. The agreed upon sampling plan should address all potential routes of entry (inhalation, dermal, etc.). Table 2 below lists typical post-fire sampling techniques and analyses. The use of such sampling techniques and analyses will depend on the circumstances of the event; not all of the analyses will be warranted for every fire event, and the analytes in Table 2 may not cover all potential fire-related analytes (i.e., isocyanates from burned polyurethanes). Some of these methods require ultra-pure and clean sampling materials and techniques. For example, when sampling for low levels of mercury, clean vs. dirty techniques are important. Therefore, when sampling multiples of contaminants it is important to consult with the analyzing lab to establish an order in which samples should be collected for the clearest analysis and results.

Sampling activities should follow a strategy starting at the source of the fire event (i.e., air compressor) then move to other areas of the facility (i.e., non-impacted areas, office areas, etc.). The source's composition, historically known hazardous components (i.e., PCBs), and the type of extinguishing agent used should be evaluated. By using this strategy, results can show where the potential contaminants are concentrated and where they may have migrated. In addition, visibly damaged building materials (i.e., drywall, pipe insulation) need to be analyzed for hazardous components (i.e., asbestos). Ruling out the presence of hazardous source materials and affected building materials quickly will reduce sampling efforts and ultimately decrease the remediation time.

Table 2 – Post-Fire Sampling Techniques and Analyses

Contaminant	Methods	Published Exposure Limits/Guidelines
Combustion/fire-related Particulates* (char, soot, ash)	Air Sampling Method: Direct-Reading Instrument (aerosol monitor) NIOSH 0500, 0600	OSHA – 15 mg/m³ (total), 5 mg/m³ (respirable) ACGIH – 10 mg/m³ (inhalable), 3 mg/m³ (respirable) CalOSHA Emergency Regulation (5141.1) – 55.5 ug/m³ (PM 2.5)[3] USEPA NAAQS – 150 ug/m³ (PM 10)
	Air Sampling Method:[3] NIOSH 7400 (char & ash) Air-O-Cell (char & ash) 25 mm MCE filter (char, soot, ash)	None Established. Can be used to measure presence, degree, and extent of suspended fire-related particulate of impacted areas vs. non-impacted areas
	Surface/Bulk Sampling Method (ASTM D6602-13): Visual Area Estimation (EPA 600/R-93/116) Light Microscopy TEM/EDX SEM/EDX	None Established. Can be used to measure presence, degree, and extent of settled fire-related particulate of impacted areas vs. non-impacted areas. IESO/RIA Standard 6001[4] (char & soot indicators only)[4]
Polycyclic Aromatic Hydrocarbons (PAHs)	Air Sampling Method: NIOSH 5506	OSHA – 0.2 mg/m³ COPC Health-Based Benchmark – 0.2 ug/m³ (indoor air)
	Surface Sampling Method: EPA 8082A Analytical Methods NIOSH 5506/EPA 8310/8270	COPC Health-Based Benchmark – 150 ug/m² (settled dust)
Metals	Air Sampling Method: OSHA ID 125G	Compare to individual OSHA & ACGIH exposure limits
	Surface Sampling Method: OSHA 121	Brookhaven National laboratory (Document IH75190; 6/23/2017) OSHA – "free as practical"
VOCs & SVOCs	Air Sampling Method: Direct-reading Instrument (PID) EPA TO-15	Compare to individual OSHA/ACGIH exposure limits. Compare concentrations of compounds at impacted areas vs. non-impacted areas. <1 ppm or <500 ug/m³ (if no significant indoor sources used in production)
	Surface Sampling Method: EPA 8082A Analytical Methods EPA 8082/8270/8260/8310/8315	Can be used to measure presence, degree, and extent of settled fire-related residue of impacted areas vs. non-impacted area
Dioxins/Furans	Air Sampling Method: EPA 8290	COPC Health-Based Benchmark – 0.001 ng/m³
	Surface Sampling Method: EPA 8290	COPC Health-Based Benchmark – 2 ng/m²
Asbestos	Air Sampling Method: NIOSH 7400 "A" Rules	OSHA & ACGIH – 0.1 f/cc EPA AHERA – 0.01 f/cc
	Bulk Sampling Method: PLM	EPA – >1% OSHA – any detectable amount
Mold	Air Sample Method: Air-O-Cell Bulk Sample Method: Tape Lift	Compare to types/concentrations to outdoor samples or non-impacted to impacted areas. Moisture evaluations can also be conducted to ensure that damaged materials do not have elevated moisture content that supports further fungal growth
Unknown Source Materials (i.e. liquids/oils – PCBs)	Various methods (consult with laboratory)	PCBs – 10 ug/100 cm² (EPA) PCBs – 1 ug/m³ NIOSH (CAS No. 11097-69-1) PCBs – 0.5 mg/m³ ACGIH/OSHA (CAS No. 11097-69-1)
Extinguishing Agents (i.e. AFFF & FFFP – PFOAs)	EPA Method SW846 8327	None

Notes for Table 2
*Sampling & analytical limitations (i.e., presumptive analyses, confirmation analyses, and media use) should be discussed with the servicing laboratory, understood, and considered before employment of combustion-related particulate sampling techniques and methods.
COPC = Contaminants of Potential Concern; selected in combination with members from U.S. EPA, New York City Department of Health, Agency for Toxic Substances Disease Registry, New York State Department of Health and Occupational Safety and Health Administration and include health-based benchmarks developed to be protective of long-term habitability of residential dwellings.[2]

Step 3 – Re-Occupancy

The decision to re-occupy some or all of a facility should be based on a combination of professional judgement, sampling results, and remediation efforts. Key steps to consider while determining re-occupancy are presented in Figure 4.

Figure 4: Re-Occupancy Steps

1. Isolation

Considering the scale and extent of the event, it is necessary to isolate the area from un-authorized personnel. After the IH professional has provided an initial opinion regarding occupancy of the heavily impacted/source area, isolation techniques may be appropriate (i.e., temporary walls, plastic containment, covering HVAC supply and return vents in construction area and surrounding area, and/or use of air filtration devices to create negative atmosphere). Isolation/containment creates a physical barrier to the most heavily impacted areas, prevents employee entry to damaged areas, and limits migration of aerosols, vapors, and odors to other areas and employee entry.

2. Remediation

Visual observations, subjective odor detection, and results of sampling and analysis will help guide the remediation effort. Cleaning methods may result in additional airborne re-suspension of fire-related particulate, which will often necessitate respiratory protection and other PPE for remediation personnel. Vacuums equipped with high efficiency particulate air (HEPA) filters and other methods to limit airborne dust should be used to clean up fire-related particulate. Following removal of damaged materials that may continue off-gassing following the initial event, dilution of the building's air and filtration methods should be employed to continue removing airborne particulates during the cleaning process. Risks from ozone-generators and other chemicals potentially used by remediation companies should also be managed and communicated to the site. Disposal of fire-impacted materials should be separate from other site waste streams. Waste should be double-bagged or wrapped in plastic where possible, utilizing a separate dumpster in case waste needs to be disposed as hazardous and be delivered to a separate landfill. Overall, remediation guidelines published by the Restoration Industry Association (RIA), Guidelines for Fire & Smoke Damage Repair, 2nd Edition are effective.

3. Clearance

Although not required by law, code, or statute, post-restoration verification of the effectiveness of cleaning and/or restoration is an established best practice that is followed in other evaluations of remedial effectiveness (e.g., mold or asbestos), and applies in this situation as well.[1] Acceptable post-restoration/clearance criteria should be discussed with the site personnel, insurance adjusters, and remediation contractors as there may not be regulations outlining all potential fire-related chemicals of concern. If sampling and analytical data are used as clearance criteria, establishing limits and defining the actions taken if those limits are exceeded is critical and shall be agreed upon by all parties before they are employed. Expectations for turnaround times from the laboratory should also be communicated to all parties. Comparing analytical results to non-impact areas vs. impacted areas is a common approach. However, distinguishing background levels from non-impacted areas can be a challenge. In addition, comparing results directly to regulatory and/or other best practice guidelines is also a common approach.

Lessons Learned

- In our experience, applying the procedures discussed in this poster to an actual fire event (compressor fire/explosion), produced a satisfactory outcome. The analytical results obtained from the initial onsite assessment supported our opinion of allowing employees to re-occupy the building and continue normal work activities. No PCBs were detected in the residual compressor oil and the impacted building materials did not contain asbestos nor were found to contain moisture content capable of supporting biological growth. Airborne particualtes were non-detectable and below PM 2.5 and PM 10 guidelines. The extent of fire-related particulates showed settled particulate was concentrated near the impacted areas and other non-impacted employee occupied areas (i.e. offices, warehouse, and production floor) showed results of none detected to below the level of detection. Fire-related particulate results helped determine the degree of cleaning levels employed by the remediation contractor. Other than in the compressor room, no odors atypical of normal office environments or the production operation were observable. Total airborne VOC concentrations were also low. The results also supported the recommendation of isolating/containing the heavily impacted areas and providing dermal and respiratory PPE during remediation efforts of those areas. Post-remediation sampling was not conducted during this described evaluation.
- Interpretation of fire-related particle (char, soot, ash) analyses of surfaces by Visual Estimation Technique (VAE) are not "health-based" in nature and their use is limited, as results are not provided as actual surface or mass concentrations, but as an estimated percentage or part of the particles observed by the analyst. More research is needed to develop acceptable background levels and "health-based" permissible limits for fire-related particulate on surfaces.

Conclusions

Having an industrial hygiene professional conduct a post-fire indoor environmental quality evaluation will help management make the critical decision of allowing employees to re-occupy a building safely. Information provided to management should be health-based and presented in a way which is easily communicated and understood by employees and stakeholders. Employing the evaluation procedures described in this poster can help ensure health-based information was considered before re-occupancy. A good post-fire indoor environmental quality evaluation requires sound understanding of specific physical information related to the fire event, development of reliable health-based sampling plans and methodology, and professional opinion regarding re-occupancy, remediation, and exposure control.

References

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