Digitized Checklists Enhance Safe and Healthy Buildings

Alessandro Agnello PhD
True Data Ops
aagnello@truedataops.com – TRUEDATAOPS.COM

TRUE DATA OPS

Abstract

Healthy buildings require continuous upkeep and inspections in order to remain healthy. They require multiple systems working in unison to keep the occupants comfortable, healthy, and productive. In this white paper we will discuss the use of "Digitized Checklists" to increase productivity, safety, and building health. Having necessary information of the building assets' being serviced is critical for technicians to perform their tasks in a consistent and safe manner.

Introduction

It is no surprise that healthy buildings increase productivity, offer elevated safety, and make an inviting workplace. Long gone are the days when you could open a window when it was hot or turn up the thermostat when it was cold. The new building design has advanced considerably over the decades and windows no longer open for fresh air. Building Management Systems (BMS) have taken over all HVAC and lighting control as well. Commercial buildings now require specialists to install, troubleshoot, and repair controls as well as document their actions.

A building automation specialist (BAS) operates building automation systems and air conditioning controls, using various operator workstations, computers, digital interface units, and standard HVAC tools of the trade. Inspects, monitors, evaluates, and adjusts mechanical systems performance for proper and efficient operation including pumps, fans, valves, dampers, terminal units, heat transfer equipment, fluid flow conditions, and air and water system balance.

Building Management Systens

Building Management Systems (BMS) are the control systems that manage the air control, fire safety, and environmental systems within commercial buildings. This is especially important within an office building environment where control of air changes is essential for occupants. Something as simple as turning up the temperature now requires increasing the reheat capability while balancing the proper airflow without disturbing the adjacent spaces. The type of air filtration will have the ability to not only remove dust particles but viruses as well. If conditioned supply air is not available through an air handler, then how do the occupants receive fresh air?

"Studies have found that in North America and Europe, we spend 90% of our time indoors. Some jobs have you outside more, and kids spend more time outside than adults — but, for most of the developed world, it is more accurate than you might think. (In some places and in seasons, 90% is actually an underestimate; in the United Arab Emirates, it can be more like 99.9% indoors for some.)" [21] With this in mind, you can see that a healthy indoor environment could determine your wellbeing.

Healthy buildings require frequent and ongoing upkeep in order to maintain a safe working and living environment. Building systems are working harder now to provide fresh air while operating with lower occupancy. Previously, in a CO2 demand control ventilation system, you might consider higher CO2 levels before increasing outside air.

CO2

The effects of CO2 on adults in good health can be summarized to:

1. Normal Outdoor Level: 350 - 450 ppm
2. Acceptable Levels: ¡ 600 ppm
3. Complaints of Stiffness and Odors: 600 - 1000 ppm
4. ASHRAE and OSHA Standards: 1000 ppm
5. General Drowsiness: 1000 - 2500 ppm
6. Adverse Health Effects may be expected: 2500 - 5000 ppm
7. Maximum Allowed Concentration within a 8-hour Working Period: 5000 - 10000 ppm
8. Maximum Allowed Concentration within a 15-minute Working Period: 30000 ppm

The levels above are quite normal and maximum levels may occasionally happen from time to time. In general - ventilation rates should keep carbon dioxide concentrations below 1000 ppm to create indoor air quality conditions acceptable to most individuals. [12]

Building management systems, such as Johnson Controls [11], under normal usage, require constant attention as they will drift leaving the occupants either too cold, too hot, and exposed, this may be defined as energy drift. "Energy drift is the gradual loss of efficiency that can occur after a Building Management System (BMS) is commissioned. After initial setpoints and schedules are established, changing site conditions, control overrides made by staff, and underperforming equipment can cause buildings to stray from expected savings over time. These issues can be combated by identifying where drift is occurring and taking action to put efficiency back on track; however, the fundamental problem is that energy and building managers don't have access to real-time, asset-level, and historical data to determine if there is an issue, what the issue is, and where the issue is coming from in order to do this efficiently." [4]

The occupant will not normally notice that the CO2 in their space has risen to unacceptable levels due to a broken fan belt or tripped breaker. However, the threat of exposure increases dramatically when the air in space is no longer being exchanged. "Moderate to high levels of carbon dioxide can cause headaches and fatigue, and higher concentrations can produce nausea, dizziness, and vomiting." [20]

Building HVAC systems have multiple failure modes to include broken fan belts (most common), tripped freeze stats, or worn-out dampers. As a manager or owner, one would like to minimize downtime. All failures increase the risk of occupants being exposed to airborne viruses.

MERV 13

Some experts recommend changing air handler unit (AHU) air filters to a MERV 13 or higher. [8] What impact does this have on your existing AHU? Are you able to move enough air throughout the spaces you are conditioning? How soon will the MERV 13 air filter become clogged with particulate and when should you replace it? Is your filter replacement automatic or do you measure the pressure drop across your filter bank? How is all this information documented and how quickly can you access it?

"We strongly recommended upgrading to MERV 13 or higher. This is a level of filtration recommended for "superior office buildings," and it removes almost 90 percent of PM2.5."[8] "PM2.5 : fine inhalable particles, with diameters that are generally 2.5 micrometers and smaller. How small is 2.5 micrometers? Think about a single hair from your head. The average human hair is about 70 micrometers in diameter – making it 30 times larger than the largest fine particle." [3]

Building owners have installed Ultra Violet C lighting (UVC radiation refers to wavelengths shorter than 280 nm) in the return ductwork to kill any viruses prior to the air entering the filter back. [15] This design assumes that the outdoor air is free from virus contaminants.

UVC radiation requires the use of Ultra Violet lighting in your return ductwork or in the occupied space to kill any viruses. UVC radiation has effectively been used for decades to reduce the spread of bacteria, such as tuberculosis. [2]

Needlepoint Bipolar Ionization and Plasma are also ways to reduce viruses in the air but they all require maintenance, testing, and documentation.[6] Ozone generators are also effective at killing viruses however, excessive ozone creation can cause issues in occupants when high concentrations are present. "When inhaled, ozone can damage the lungs. Relatively low amounts of ozone can cause chest pain, coughing, shortness of breath, and throat irritation. It may also worsen chronic respiratory diseases such as asthma as well as compromise the ability of the body to fight respiratory infections." [19]

Digitized checklists are critical in documenting planned/preventive maintenance. Checklists are key to ensuring that technicians follow the same maintenance and safety procedures for each individual task. The digitized checklist should include the required Personal Protective Equipment (PPE) with instructions on how to put it on and use it. Because the digitized checklists are on-line they can be accessed from anywhere and by third party if needed. Digitized checklists can also incorporate building plans, emergency contact information, and spill prevention.

Reactive vs Planned Maintenance

As building systems are working longer hours at increased ventilation levels, they will observe higher rates of failure. [19] This also opens the door to more scheduled maintenance to reduce reactive maintenance. Typical reactive maintenance will happen off-hours and at the most inconvenient times. There is also a large increase in costs associated with reactive maintenance or emergency repairs.

"Run it until it breaks" is a popular maintenance mode that requires no effort at all on the part of facilities. That is until the asset breaks at the most inopportune moments. Typically, there are no replacement parts immediately available and the cost of repair off hours is doubled. Still, this type of maintenance is preferred practice.

Advantages

- Low cost.
- Less staff.

Disadvantages

- Increased cost due to unplanned downtime of equipment.
- Increased labor cost, especially if overtime is needed.
- Cost involved with repair or replacement of equipment.
- Possible secondary equipment or process damage from equipment failure.
- Inefficient use of staff resources.

Figure 1: This figure represents the Advantages and Disadvantages of Reactive Maintenance. [14]

Advantages

- Cost effective in many capital-intensive processes.
- Flexibility allows for the adjustment of maintenance periodicity.
- Increased component life cycle.
- Energy savings.
- Reduced equipment or process failure.
- Estimated 12% to 18% cost savings over reactive maintenance program.

Disadvantages

- Catastrophic failures still likely to occur.
- Labor intensive.
- Includes performance of unneeded maintenance.
- Potential for incidental damage to components in conducting unneeded maintenance.

Figure 2: This figure represents the Advantages and Disadvantages of Planned Maintenance. [14]

"Studies indicate that these savings can amount to as much as 12% to18% on the average. Depending on the facility's current maintenance practices, present equipment reliability, and facility downtime, there is little doubt that many facilities purely reliant on reactive maintenance could save much more than 18% by instituting a proper preventive maintenance program." [14]

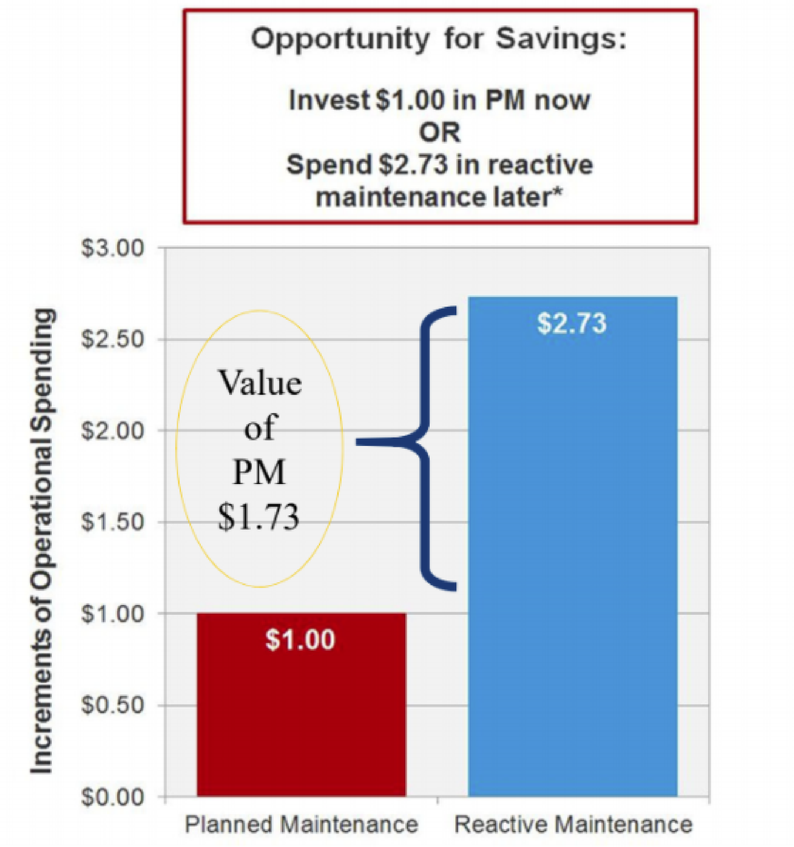

Figure 3: This figure represents the cost savings upon succesful planned maitenance [17]

As technicians provide services and repairs for building assets, it is critical that they have the correct procedures and training. Training and procedures are the responsibility of the employers. Having the maintenance and fault history of a piece of equipment will save downtime and increase worker productivity and accountability. This history is also required by most state environmental authorities.

Low Water Cutoff

Standardized and organized workflows, create safer working environments while maintaining buildings. Workflows vary from technician to technician with little or no training available, increasing the risk of injury and creating potential unhealthy environments. When a technician is unable to read a temperature or pressure on a steam boiler because they do not know where the gauge is located, it creates an unsafe environment for everyone. "Watch out: if the low water cutoff valve is not flushed often enough, the residue of solid debris (minerals, rust, dirt, also referred to as "TDS" or total dissolved solids) can clog the low water cutoff valve so that it will stop working and could fail to sense an unsafe low-water condition in the heating boiler. The low boiler water level can lead to costly boiler damage or even a BLEVE explosion." [13]

If an event occurred there would need to be a digital account of inspections and testing readily available. The preferred method for recording an action like manually tripping a low water cutout would be video. That action cannot be recorded on a paper checklist. A video could be made of the maintenance of the valve verifying that it was flushed and functional. Testing low water cutouts are based on the manufacturer's recommendations, either daily or weekly.

Air Filter Replacement

Changing air filters is no longer just as simple as putting on a dust mask, pulling it out of the air handler, throwing them in a garbage bag, and tossing them in a dumpster. With the potential COVID-19 hazard in every building, this simple task has just turned into a hazardous undertaking. Should every air filter be changed out and be treated as if it were infected with COVID-19? Strict guidelines and organized procedures must be followed in order to keep the technicians and occupants safe. Procedures may require technicians to wear a protective suit with a sealed mask in order to pull out the used air filters. Most notably the Air Handling Unit will have to be safely turned off with the appropriate lockout tag-out procedures followed. [1]

What type of air filter is recommended by OSHA or ASHRAE? Can used air filters be disposed of with the regular trash? Building owners and managers are responsible for developing Standard Operating Procedures for their employees. How do you, as a building manager or owner, ensure that your technicians are installing the correct air filters? How do you ensure that they are being disposed of properly? Are you disinfecting your air handlers prior to performing maintenance on them? From a healthy building standpoint, it is critical that systems are disinfected more often and create a safe atmosphere for the occupants and workers. Digitized workflows and asset management is the key to creating and maintaining a healthy and safe environment. [10]

PPE / SDS

In the event of a chemical spill, it is critical that the response has adequate documentation and PPE to manage the situation safely and timely. [5] There may be a training video specific to a particular chemical that needs to be readily available. The faster it is to view the Safety Data Datasheet (SDS) the better. Having it on a mobile device allows for multiple technicians to view the same SDS at the same time.

Energy efficiency is now taking a back seat to safe and healthy buildings with good reason. [9] The last operation a building manager would want to do is recirculate contaminated air and that would require the addition of almost 100% outside air. Unfortunately, most AHU's are not designed for 100% outdoor air and some of those conditions include:

1. Air below 32 Degrees F entering the air handler may cause the freeze protection to turn the fan off. This action is to protect the air handler coils from freezing. Unfortunately, if the fan is shut off you have no air at all going into an occupied space.
2. Northern states have to contend with snow plugging the air filters of an air handler creating a state of no air flow through the air handler.

Which energy efficiency measures should be performed without affecting the occupants safety? A few examples that get overlooked include:

1. Ensure the cooling tower fans, condenser pumps, and evaporator pumps turnoff when the chiller turns off. If there is no call for cooling quite often these devices stay running.
2. Do the fans, pumps, and chillers have VFD drives on them? Are they actually modulating to a desired control point? Do your VFD drives operate at 60Hz or above all of the time? With the assistance of a skilled building automation technician, this can easily be rectified.
3. To take the VFD drive control issue one step further, do the AHU supply and return fans modulate as well? What is their control point of the drives on these devices?

Building air conditioning in one of the largest drivers of energy usage in a building compounded by higher electricity demand charges in the summertime. Therefore, building cooling control is key to saving energy. [7]

Conclusion

From an efficiency standpoint, "The quality of air within an office can have a significant impact on your employees' health and in turn productivity. Research carried out by the World Green Building Council recorded an 11% increase in productivity as a result of increased fresh air to the workstation and a reduction in pollutants." [16] In order to accomplish a consistent environment, BMS controls cannot be ignored. Building technicians have to be responsive to occupants issues. Scheduled preventive maintenance is key to a well running healthy building. Cloud based digitized checklists are the only way to standardize and schedule preventive maintenance.

True Data Ops addresses this by delivering a data-first, collection, storage, and retrieval solution via mobile and cloud technologies. We digitize your existing checklists with associated data (e.g., user manual, building plans, spill prevention guidelines) for fast and easy online access anywhere. We enhance your checklists with the ability to take pictures, videos, and custom-tailored input ranges (e.g., expecting a range of 160 - 180 deg F). Upon submission of your checklist, our patent-pending platform will determine if an immediate fault is recognized. True Data Ops will generate alerts/work worders and notify users within your organization. View all your organization's assets faults in ONE screen. True Data Ops has all of this without the need for Internet connectivity, allowing your technician's daily operations not to be burdened, but complimented.

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