

How the Spring Fire Department Achieved a Healthier Cab

A Real World Case Study on the
Sentinel 300 with NPBI Technology

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— TOXIC —
SUPPRESSION



66%

THE FIRE SERVICE AND CANCER

of career firefighter LODDs from
2002 to 2019 were due to Cancer

Cancer is the most dangerous threat to firefighter health and safety. While saving lives and property, firefighters can be exposed to hundreds of potentially dangerous substances. They face exposure to high levels of Volatile Organic Compounds (VOCs), carcinogenic particulates, and contagious pathogens because fireground gases, vapors, and particulates contain many substances known or suspected to cause cancers.

Additionally, Polycyclic Aromatic Hydrocarbons (PAH) are a group of chemicals formed during the incomplete burning of organic substances such as coal, oil, gas, tobacco, and even garbage. While naturally occurring, PAHs can make their own small air particles and form chemical compounds, such as benzene and formaldehyde that can cause cancer.

The International Agency for Research on Cancer (IARC), an agency of the World Health Organization (WHO), has re-evaluated firefighting and classified firefighter occupational exposure as a group 1 carcinogen, stating there is sufficient evidence for cancer in humans.

“ Air concentrations of BTEXS (benzene, toluene, ethylbenzene, xylene, and styrene) measured off gassing from firefighters’ used PPE (Personal Protective Equipment) and in firefighters’ postburn exhaled breath were significantly correlated. Firefighters should be made aware of the potential for inhalation exposure when doffing and traveling in confined vehicles with contaminated PPE and take measures to minimize this exposure pathway.

-- “Volatile Organic Compounds Off-gassing from Firefighters Personal Protective Equipment Ensembles After Use” by Kenneth W. Fent, et. al, Journal of Occupational and Environmental Hygiene 2015, 12: 404–414

Thankfully, first responders are being educated on these dangers. Most are taking steps to help minimize exposure such as following NFPA 1851 cleaning and care guidelines for soiled structural firefighting PPE. Still, there is much to learn and much more must be done to mitigate these risks while being mindful of the job that must be done.

A Clean Cab Vs A Healthier Cab

THE PHRASE “CLEAN CAB” IS ONE OF THE MOST POLARIZING PHRASES IN THE FIRE SERVICE.

The mere mention of the phrase “Clean Cab” can set off the most heated of debates at the firehouse kitchen table. The Clean Cab concept was created to minimize exposure to cancer-causing toxins. This concept is based upon separating contaminated PPE and SCBAs from the riding compartment so first responders are not repeatedly exposed to VOCs, PAHs, and carcinogenic particulates.

TVOC's documented as offgassing from PPE ¹

styrene
benzene
1,4-dichlorobenzene
acetone
cyclohexane

What makes this concept such a topic of debate is the clean cab concept requires firefighters to change the way they do their jobs. Some will say “clean cabs don’t make grabs” or “what will the victims’ families say while precious seconds are lost gearing up at a scene.” Others will argue that with a healthier cab firefighters better protect themselves and are better able to protect their community.

Many fire departments modify the Clean Cab concept to best fit their constituents needs and budget. Some segregate their turnout gear from the cab while still carrying SCBAs in the jump seats such as the department that is the subject of this study.

This study’s goal is to show there are steps that can be taken to protect first responders without drastically changing or impeding how they do their job.

¹Kenneth W. Fent, et al. 2015. Volatile Organic Compounds Off-gassing from Firefighters’ Personal Protective Equipment Ensembles after Use. Journal of Occupational and Environmental Hygiene, 12: 404–414

THE PROBLEM

How does the Sentinel Purifier make for a healthier cab?

Using Needle Point Bipolar Ionization to reduce TVOCs.

Since what you can't see can still harm you, the Sentinel Purifier uses Needle Point Bipolar Ionization (NPBI) from **GPS Air, Inc.** to reduce the three types of airborne contaminants: particulates, TVOCs, and pathogens. This air and hard surface sanitizer has no filters or bulbs yet actively reduces those threats you can't see with the naked eye.



Our goal was to validate the performance of the Sentinel Purifier and visibly show how NPBI technology make the fire apparatus a healthier working environment.

STEP 1 - THE PROCESS

Vehicle Air Quality Data Capture

To find a way to measure TVOCs in real time and capture baseline data of what firefighters are routinely exposed to, we partnered with Attune to launch the **Sentinel IQ powered by Attune**, which monitors and alerts in real-time to airborne threats. The Sentinel IQ is designed for fire apparatus, ambulances, fire stations, or anywhere you want to monitor air quality or to validate air purification performance. The data we are amassing is teaching us things that will change how first responder agencies think and operate.

Some of the things we learned include:

1. The need to ventilate a hot cab before entering! Ambient temperatures that exceed 105 degrees will result in extreme off-gassing. This is not just from contaminated PPE. Anything in a vehicle that can off-gas...will.
2. Average TVOC's in a fire apparatus are nearly double what the EPA considers "Unhealthy for Some Groups"
3. Post-fire VOC levels max out the TVOC sensor and levels can remain elevated above what the EPA considers "Unhealthy" for hours afterwards.

The collection of baseline results of what firefighters are routinely exposed to is key to proving how this first of its kind air quality monitoring system for fire apparatus technology works. In February we approached the Spring Fire Department just north of Houston, Texas about partnering with us for a real-world test.

For baseline data collection, a **Sentinel IQ-Ion** Vehicle Air Quality Monitoring System was installed in the Spring Fire Department's Engine 71, their fleet's busiest apparatus. The central focus was the TVOC and ion concentration levels.



Sentinel IQ Install in Spring FD E-71



SENTINEL IQ-ION

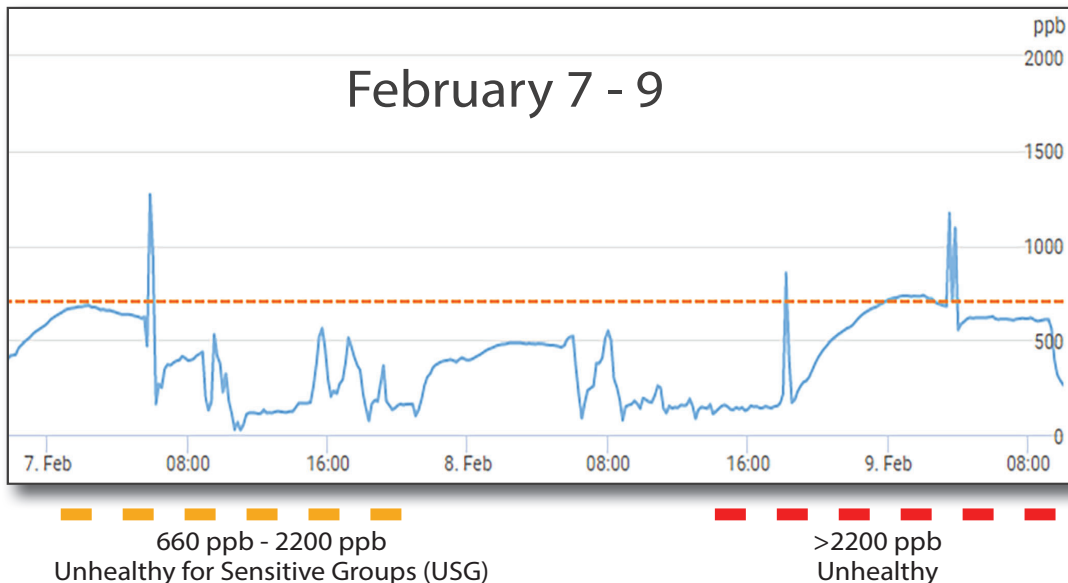


SENTINEL IQ GATEWAY

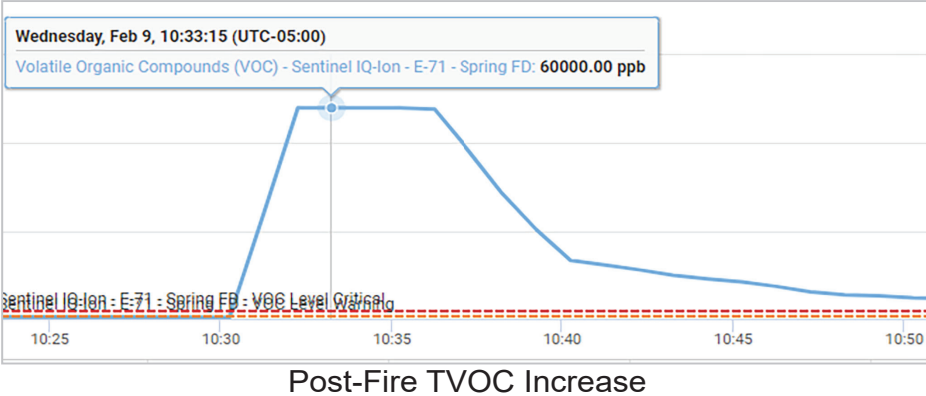
In order to capture as many conditions and call types as possible, the Sentinel IQ was installed on February 7th and data was captured through May 6th.

Thresholds were set based on EPA Guidelines, indicated by the yellow and red dashed lines. Data from the first few days TVOC levels mostly remained at safe levels with a few peaks over the “Unhealthy For Sensitive Groups” threshold of 660 ppb*. The Fire Department was very impressed to see the collected data.

*TVOC thresholds based on World Health Organization (WHO) IAQ guidelines



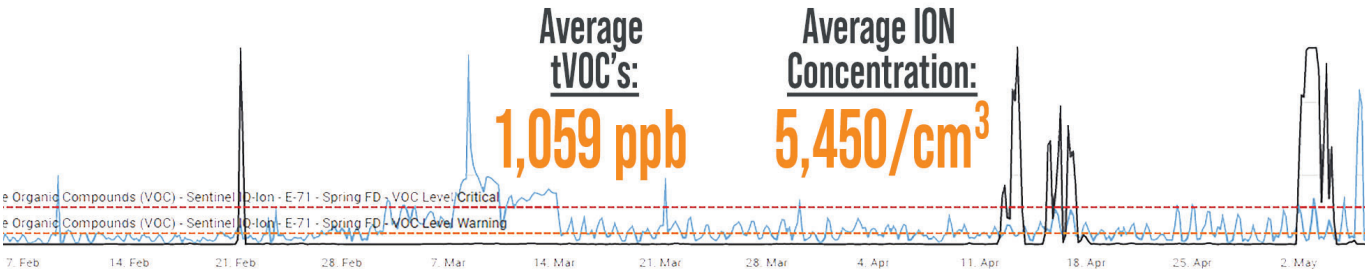
At approximately 10:00 am on February 9th, there was an event that confirmed everything. Engine 71 responded to a structure fire where crews were exposed to fire and heavy smoke. Per their Standard Operating Procedure they doffed their turnout gear, bagged it, and stored it in a separate compartment. At 10:30 am they placed their lightly deconned SCBAs back into the cab to return to the station.



Within 2 minutes the TVOC sensor went above the maximum at 60,000 ppb and remained above maximum for 5 minutes before the TVOC levels began dropping. Even more alarming the TVOCs remained well above unhealthy levels for over an hour just due to SCBAs being in the cab.

It was at this moment when we realized that this was what firefighters have been breathing in their fire apparatus, their Chief’s vehicles, and in their own personal vehicles...for generations.

The chart below illustrates TVOC levels throughout the 3-month period of baseline data collection. The average TVOC level of **1,059 ppb** was nearly double what the WHO considers “Unhealthy for Some Groups”. Ion concentration averaged **5,450 ions/cm³**, a level considered atmospheric as ions are naturally occurring in the environment.



Baseline TVOC and Ion Averages February 7th - May 6th

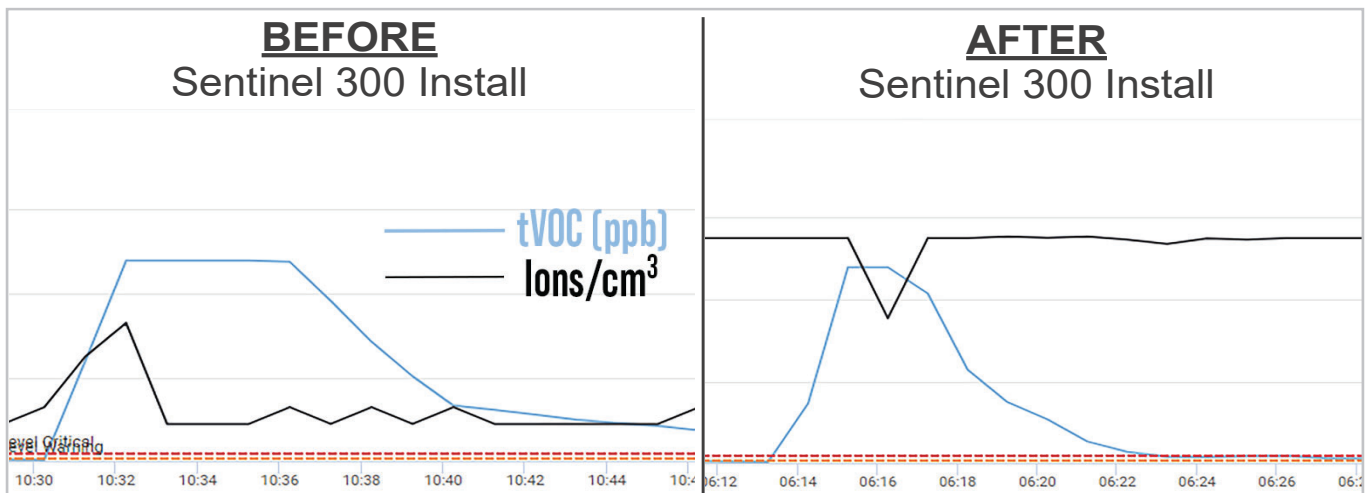
STEP 2 - CORRECTIVE ACTION

Sentinel 300 Installation

With the Step 1 baseline data collected, Step 2 was to install a Sentinel 300 Air and Hard Surface Sanitizer with Needle Point Bipolar Ionization into Engine 71. The purpose of this initial test was to focus on how effective the NPBI generated ions were in reducing TVOC's without the use of filters or bulbs.

By using the already installed Sentinel IQ Vehicle Air Quality Monitoring system we can for the first time see how the NPBI generated ions interact with the TVOC's in real-time. Below is a comparison of post-fire events.

Post-Fire In Cab TVOC Levels



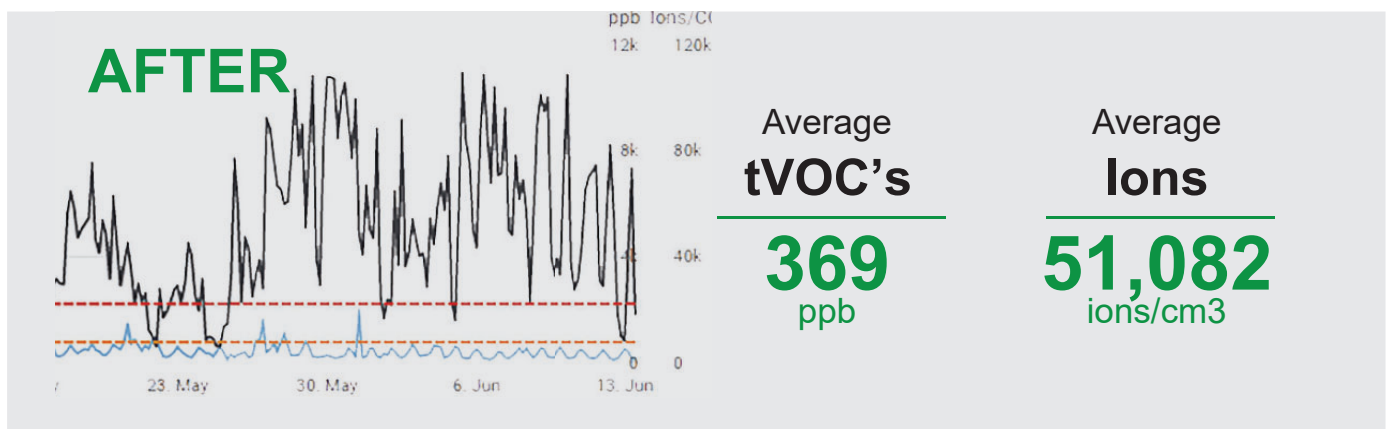
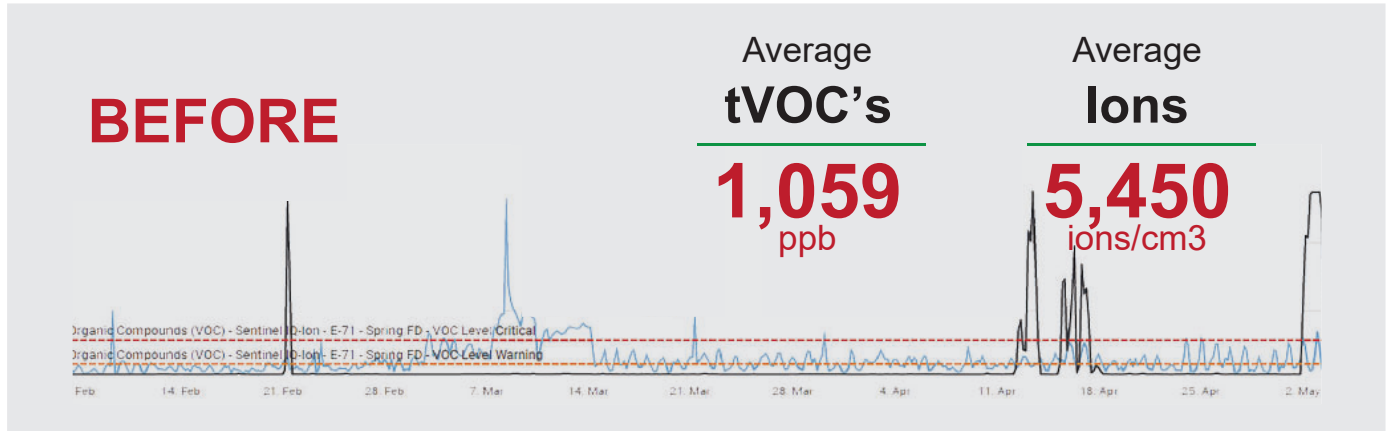
Prior to the Sentinel 300 being installed, post-fire TVOCs rapidly increase to maximum before very slowly tapering down over the course of hours.

Using the Sentinel 300 post-fire, TVOCs still rapidly rise, but within minutes TVOC levels return to safe levels. The time TVOCs are present is and the decline of TVOC levels is nearly as steep as the increase.

With the ion sensor we can now see the drop in ion concentration as the ions interacting with the TVOCs are lost. This correlates exactly to the drop in TVOCs after the ions in the air catch up and quickly eradicate off-gassing TVOC's.

OVERALL TVOC REDUCTION RESULTS

In comparing the overall results based on the average level of TVOCs present before and after the installation of the Sentinel 300, the results were easy to see.



TVOC
Reduction
65%

As clearly illustrated, the NPBI generated ions from the Sentinel 300 directly correlate to reduced levels of TVOCs. With spikes rarely exceeding 660 ppb, TVOC levels remained much more stable. Overall, the average TVOC level of only **369 ppb** offered a **65%** reduction in TVOC's in comparison to baseline.

Additionally, the average ion concentration of **51,082/cm³** was nearly twice the ion concentration's used in the most effective NPBI efficacy test (27,000 ions/cm³) performed by Innovative Bioanalysis against SARS-CoV-2 in which the virus was neutralized on multiple hard surfaces to at least 99.89% in 30 minutes.

CONCLUSION

The Process - Lessons Learned

To start this study, we were not sure how firefighters and fire departments would see the value of the information we set out to provide. That concern was alleviated almost immediately as every person we spoke with at the Spring Fire Department appreciated and took great interest in what we were trying to accomplish.

When the first fire call happened, to see their reaction and alarm when presented the data to what kind of environment they have been working in told us that we were on the right track. The biggest takeaway from our perspective is these levels and spikes in TVOC's were from SCBA's in cab alone, not their turnout gear which was bagged and stored. Further tests are scheduled to determine the entire scope of what can be encountered.

Corrective Action - Sentinel 300

The fact Sentinel 300 was working was evident from the start. With the **Sentinel IQ powered by Attune**, we could finally see that the NPBI generated ions from the Sentinel 300 greatly reducing TVOC levels in cab. Firefighters could noticeably tell the difference in that the truck no longer smelled of strong soot and smoke for days.

Equally as impressive, the average temperature during baseline period was 78 degrees and 93 degrees for the period after the Sentinel 300 was installed. Despite a 15 degree increase in the average temperature (which usually correlates to higher TVOC levels) the Sentinel 300 was providing a safer working environment.

A Healthier Cab Validated

The **Sentinel 300 provided a Healthier Cab** by reducing average TVOCs 65% without the use of replaceable filters or bulbs. This Healthier Cab was achieved with no input or action from any personnel on duty proving the Sentinel 300 can provide a safer working environment without impacting the way firefighters do their jobs.

Additionally, thanks to the **Sentinel IQ powered by Attune**, the Sentinel 300's effectiveness in reducing TVOCs was validated in a real world environment.

About

SPRING FIRE DEPARTMENT

Since 1953

The Spring Fire Department is located in Spring, Texas, approximately 25 miles north of downtown Houston. Founded in 1953, Spring Fire Department is one of the largest combination fire departments in the state of Texas serving over 150,000 residents across 62 square miles of unincorporated Harris County.



Over the past decade, Spring Fire has transitioned from a predominantly volunteer department to a combination department where career firefighters and volunteers serve a vibrant community that multiple Fortune 500 Headquarters such as ExxonMobil, Southwestern Energy, and HP proudly call home. The Spring Fire Department wants their firefighters to serve safely and retire knowing they have many years ahead.



Toxic Suppression selected the Spring Fire Department for this study as they have made firefighter health and safety their top priority. We are proud to partner with to help raise awareness to the risks associated with firefighting and we thank

them for their interest and their hospitality in providing their equipment which made this study possible.