



Spray Booths - Design Requirements and Options

An Online Continuing Education Course for Engineers

Course Number: MA-3003
Credit: 3 Hours / 3 PDH / 3 CPD

Spray Booths – Design Requirements and Options

John Vonasek, P.E.

1. Situation

There is a meeting about to get underway in the shop where the old spray booth stood. Last Saturday there was a fire. It didn't damage the building, but the spray booth was destroyed and one employee was injured. The fire started inside the booth, where the employee was cleaning and removing the paint buildup on the walls. He escaped with a minor burn on his hand and was back to work on Monday, but the sprinkler water made a mess of the area.

Manny, a manufacturing engineer employed by the company who performs a variety of engineering duties for them, was called by the plant owner on Sunday and asked to handle the engineering issues that were arising. The owner was anxious and quite concerned about the whole situation. There would likely be lawsuits brought by the employee and insurance companies, OSHA was already at the site and assessing hefty fines for the safety violations, and then there was the matter of getting the area cleaned up and another spray booth installed in order to keep his operation running and customers satisfied.

Manny knew little about proper paint booth design, so he called Connie, a licensed P.E. and an acquaintance of his who lived in the city. Her role was a consulting mechanical engineer who was also familiar with the electrical codes. She was to create some drawings and specifications for the new booth and help with the permits and bidding process. Together, they did some research on spray booths, but needed to involve an expert in booth design who could hopefully assist with expediting the delivery of a new spray booth. They found a spray booth manufacturer who could help them and who could send their ace engineer, Boots, out on short notice to the site for the meeting.

This is a common scenario after a fire. In addition to the three engineers, representatives from the fire department, OSHA, insurance companies and the employee performing the cleaning will likely be in attendance. In our story, since we want to move into design issues, let's wrap up the loose ends by saying that a cigarette butt was found inside the booth and the booth was being cleaned with a highly flammable paint thinner (true events). Any litigation is beyond the scope of this course.

The remainder of the course will be questions and discussions between the three engineers:

Manny – Manufacturing Engineer representing the owner

Connie – Consulting Engineer

Boots – Booth Design Engineer

Manny: What does a spray booth do for us? Is it a requirement or just a good idea?

General Overview

Boots: There are legal requirements that will have to be met to allow your company to erect and operate the booth. There are also a number of things that it can provide for you to improve your finished parts and your operation.

Connie: Let's start with an overview of the legal issues so I can get started on my work.

Boots: Very good. Fire safety should be on everyone's mind. As you can see with your last booth, the walls are not constructed like other walls in the plant that separate different types of occupancies. The offices are separated from the shop with fire-rated block walls. The area enclosing your barrels of paint and thinners is surrounded by walls made of fire-rated gypsum board and steel studs. The booth is just sheet metal and has some openings for the continuous conveyor to pass through, so there is not really any fire-rated construction used in the walls. There are, however, standards and codes written for spray booths that incorporate other features to prevent fires in them. The National Fire Protection Association (NFPA) has developed a "Standard for Spray Application Using Flammable or Combustible Materials" also referred to as NFPA 33, that is widely used and incorporated into most codes. It is primarily concerned with fire safety and deals with types of construction, explosion hazards, electrical and mechanical issues as well as fire suppression and proper procedures for finishing operations. Building and fire officials want to see that this standard is met before granting a permit to allow the booth to be constructed.

There are legal environmental issues as well. There are limits on the amounts of gasses from spray operations that are allowed in the general workplace for health reasons. These gasses are Volatile Organic Compounds (VOC's) and the paint booth needs to contain them before discharging them to the outdoors. The discharge outside may also have some legal issues. Going beyond simply keeping paint particulate from settling on employee's vehicles, the booth filtration system may have to filter most of the finest particulate if it is from a paint that is classified as a high health hazard. Similarly, the voc's may also need to be monitored, dispersed or even collected before discharging to insure proper levels are not exceeded. For example, in the state of Texas, stacks for spray booths must extend to an elevation 50% higher than the building. The EPA lists "nonattainment areas" where possible treatment of the voc's may have to occur for any new or increased spray operation. These environmental regulations are generally enforced by each states *air quality or natural resources* department. They will limit how much you can emit and grant a permit to operate the booth. (Just one note: This permit may require that computer models be created to determine the effects of the additional voc's on the surrounding areas, that public meetings occur, that notices be published in the newspaper etc. Even without all that, it is reasonable to plan on 6 months to obtain the environmental or operating permit.)

Manny: I brought my shop foreman and one of our painters in here to hear how a new booth can function to improve our operations.

Boot: Great! I will go over some generalities now and we can go over them in detail later. Let's start by having everyone think about the direction of airflow inside the new booth. The air can enter and exhaust from almost any direction (see the "booth types" chart included in this course). Cross-drafts or end-to-end airflow booths are generally the least expensive. Down-drafts or ceiling-to-floor airflow booths are the most expensive and side-drafts or top-to-side airflow booths are between. If your parts are large and you have to paint from all four sides, the air should probably flow downward and exhaust at the floor. If your part is thin and primarily needs to be painted from the sides, airflow from front to back is also acceptable. If the part is always painted from one side, air could enter from above or behind the painter and exit on the opposite side. Keep it general for now because the next item to consider is the light location which may affect the exhaust location. Again, lighting can be placed in ceilings, walls at any height, hips and corners of the booth and even inside floor pits if painting is required on the bottom of the part.

Does your incoming air need to enter the booth directly? Some plants have the booth located at one end of the building with the make-up air units placed at the other end. This way, the factory air can be exhausted through the booth. The downside is that the air entering the booth is not as clean and elevating the temperature in the booth for curing is not practical.

Give some thought to the large product entry doors. Do you need them at both ends for a "drive-thru" operation or is one end enough? Manual swinging doors are the most economical, but is there room to swing them? Would powered doors work out better?

Now do a quick sketch of a booth in its approximate location and using the "booth types" chart as a guide, add in the chambers, including any pits required in the concrete. The amount of room available for the entire booth to fit will often dictate the booth type allowed. Also, if high volumes of spray are being applied, a water-wash chamber with all of its requirements should be considered. We will look at this in a little more detail later.

You might be interested in some economy features that come at a cost, but may be effective here. There could be two different levels of lighting, using fewer lights during preparation stages. Airflow in the booth could be reduced by say 50% every time the spray gun is not in use and setting on a wall hanger switch. The make-up air unit must be listed for this use if personnel are to be inside the booth when the airflow is reduced, so this option may not be possible to simply add later. Air can be re-circulated inside the booth during a curing cycle if needed and also during the paint operations. Air from the exhaust is run through a higher level of filtration, and then cycled back through the booth. This option requires more ductwork, air sensors, additional controls, breathing air and special suits for the painters and clearly defined shop procedures, but can save 50% to 90% of the make-up air fuel usage. It can also save substantially on equipment costs if the incoming air needs cooling, humidity levels controlled or if the discharged air from the booth must be incinerated for environmental reasons. One more item regarding energy usage is the use of a double-skin panel. It contains a little insulation and also hides panel flanges to create a cleaner appearance on the outside.

The last group of options that I want you to think about has to do with the structural support of the booth. Many booth suppliers will not offer structural options, but these options can make a custom booth very cost effective. Some examples include:

- Self-supporting booths (even taller than 60 feet and wider than 100 feet).
- The booth can support conveyors and hoists which may eliminate conveyor and hoist supports placed inside the booth.
- Pneumatic personnel lifts can be attached to the walls of the booth, possibly eliminating the use scaffolding.
- Make-up air units can be supported by the booth ceiling, saving on factory floor space and additional ductwork.
- We see a substantial number of booths with crane slots in the ceiling. This will allow an overhead building crane to bring a heavy part directly inside the booth without having to have the part set on a cart and rolled in.
- Large product entry and exit doors can be placed in multiple walls.
- Your local jurisdiction may request that the booth be engineered to resist seismic loads or wind and snow loads if the booth is placed outdoors.

Don't automatically assume that the booth is strictly a sheet metal enclosure. Please ask if you think the booth could facilitate making your operation flow better for you.

Connie: Before we start discussing the details of the codes, I would like to know which codes are required by law and which aren't. I will have to get approval from our city plan reviewers and need to stay focused on that.

2. Codes and Standards

Boots: Ultimately, your Authority Having Jurisdiction (AHJ), who in your case is a city plan reviewer or fire marshal, will have to give you a permit to construct the booth. The State or possibly a region will be responsible for issuing a permit to use the booth and discharge pollutants. Then there is you Connie, as the engineer of record for the project who may be called on to place your engineering seal on the drawings and specifications. You need to be comfortable with your codes and standards sources if you are to take on the liability and be able to defend your design properly.

Let's begin with the **AHJ**. They enforce whatever their local government body has adopted. In almost all U.S. locations, this is the series of International codes. The International Code Council is primarily made up of building officials throughout the United States. There is the possibility that the local government body has adopted the NFPA 101 Life Safety Code instead, but this is rare. The adopted code may be called the Los Angeles Building Code or the Florida Building Code, but they are copied from or very close to the International Building Code. I have only seen a couple of occurrences where the sections regarding spray booth design have been changed by local authorities from the original International Codes. What I do hear from other manufacturers of spray booths and people trying to sell booths is "local codes dictate much of

the design and we can't possibly know what all the local codes are." This is almost always a cover for "I don't know the codes for my product". The AHJ does have the power to require that the approval drawings and/or specifications be sealed by a P.E.

The **International Codes** were first published in 2000 and are updated every three years by the International Code Council (ICC). The International Codes (ICC) replaced the three separate national codes being the Basic Codes (BOCA), the Uniform Codes (ICBO) and the Standard Codes (SBCCI), none of which are produced any longer.

The 2015 International Building Code (IBC), Section 307.1 doesn't discuss spray booths, but it does discuss the classification of high hazard group H occupancies. It specifically refers buildings and structures occupied for the application of flammable finishes to section 416 and the International Fire Code (IFC). Section 416 mentions spray booths and also refer us to the IFC.

The IFC defines a spray booth as a "mechanically ventilated *appliance*". This can be useful when discussing the building department approval process. An electrical or mechanical approval may only be required if the booth is viewed as an appliance. It can sometimes be difficult to argue this in high seismic areas where the building department may see it more as an enclosure with occupants inside.

Chapter 24 of the IFC gets into the details of paint booth requirements. Section 2404.3 states that the design and construction of spray booths shall be in accordance with Sections ... and NFPA 33, thereby finally incorporating the NFPA standard into the legally adopted code. Most of IFC Section 2404.3 is the same as NFPA 33 anyway. NFPA 70, also known as the National Electrical Code, is the reference standard for electrical design in the International Code as well. Just a couple of points about IFC content not found in NFPA 33. There are criteria for maximum booth size and % of floor area that can be used for spray booths. This can break a project, or at least change it substantially. This will be discussed when we get into the fire-rating aspects of design. Also, IFC 2401 states that the IFC does not apply when spraying liquids with no fire point or with a flashpoint greater than 95 degrees F.



NFPA 33, The Standard for Spray Application Using Flammable or Combustible Materials forms the basis for the many building codes, including those in the US, Canada and Mexico. The standard primarily concerns itself with fire safety issues. The NFPA 33 committee is comprised of a wide range of people from manufacturing, insurance, consulting, listing services, local building departments etc., and they publish and updated standard every 3 years.

This standard states that it applies when using more than one liter of flammable or combustible liquid in an eight-hour period. When asked about the applicability of the standard when using water based paints that are not very flammable, the committee response was that the standard still applies whenever there are any volatile organic compounds (VOC's) present in the paint. Water based paints do contain VOC's, though not as much as oil based paints.

The Occupational Health and Safety Administration (OSHA) was originally published in 1972 and is based on worker safety, as recognized by many states and government agencies. Many states and government agencies have their own codes and do not need to comply with the OSHA standards. Some states are listed like the building codes and NFPA codes, and some states have their own codes regarding their own code interpretation.

OSHA uses a "compliance" approach, meaning that they recognize standards and codes as well as other standards like NFPA and ASTM). Business codes are as long as the new one is at least equivalent to the old one since the OSHA standards (section 1910.101) are more for items like spray booths. OSHA is referenced more for items like approval agency and also, OSHA is not an approval agency for a spray booth. The OSHA is not an approval agency for a spray booth. The OSHA notifies them of a violation if they wish.

I have seen advertisements for spray booths that provide approval or listing and state they are "compliant" with NFPA 33.

Connie: Does the new standard require a seal? Can the booth manufacture

Boots: An engineer's seal is not an International Fire Code or NFPA requirement for a booth. In past codes, it was stated that any booth that was also used for curing needed a listing, but that has been removed. Some local municipalities like Phoenix, requires that a spray booth be listed or signed off by a third party engineer after reviewing the final installation. At the current time, ETL and Met Labs will perform field listings but UL will not. This should be investigated early, before a sale or contract is made because it can cost a few thousand dollars and none of the parties involved believes that they are responsible for the cost.

I have a few comments regarding a manufacturer's engineer's seal. This can be done to a limited extent. Manufacturers seldom carry any errors and omissions or liability insurance for their engineers. Their products are normally insured, and that includes engineering performed on the products, so asking for the booth drawings to be stamped is likely acceptable. Where the line gets crossed is when a drawing shows an existing building wall or ceiling or door opening, if the licensed engineer cannot personally verify that it is correct. Drawings of foundations that show slab and wall thicknesses or reinforcing bars that are supplied by others

To view the remainder of the course material and to take the quiz for PDH credit, you must purchase the course.

Close this window and click "Add to cart" on the product page.