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BURN-OFF OVEN SELECTION

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How to select a burn-off oven for stripping hooks, racks, and rejects

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If your company is replacing its wet-paint system with a powder-coat system, changing the method used to clean powder-line fixtures and rejects, or planning to eliminate the cost and inconvenience of off-site stripping services, you may find yourself with the task of selecting a burn-off oven. A unique type of process equipment, burn-off ovens present a variety of choices for the buyer. This article is designed to help you select the best oven for your application.

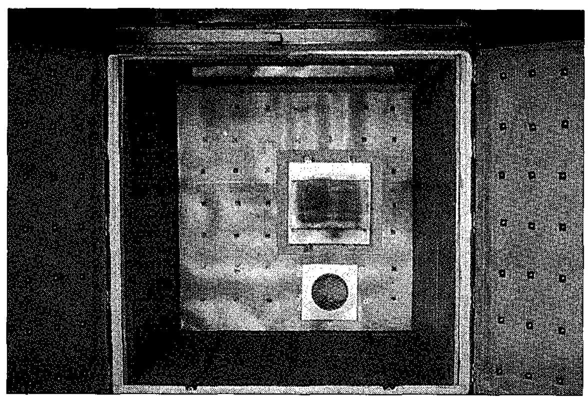
The hooks and racks, or fixtures, that carry parts through a powder coating line accumulate overspray and lose the conductive surface required for a proper electrical ground. Loss of ground results in poor transfer efficiency, uneven coverage, and the potential for arcing, which can cause a fire in the powder booth. The severity of these problems varies with the powder type, parts type and shape, and fixture design. Cleaning fixtures on a regular basis is the solution.

Some companies clean their fixtures on a scheduled basis, such as twice weekly or every four passes through the powder coating line. Others wait until there is problem, such as poor coverage or powder-chips contamination. To prevent arcing, the National Fire Protection Association (NFPA) recommends that total system resistance to ground shouldn't exceed 1 megohm.[1] The best way to measure system resistance is with a high-voltage (500 volts) megohm meter. [Editor's note: For more information about grounding, see Nick Liberto, "How important is the proper ground?" *Powder Coating,* vol. 2, no. 2 (April 1991): 46-48.]

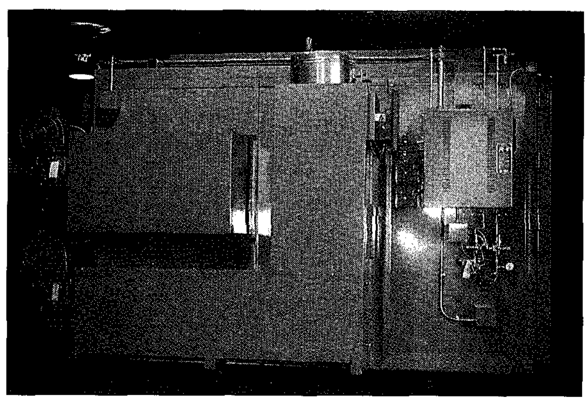
Using heat-cleaning ovens, commonly known as burn-off ovens (see Figure 1), is one of the most popular ways

FIGURE 1

A burn-off oven for stripping hooks, racks, and rejects



Interior view



Exterior view

to clean and strip fixtures. This method is also used to strip powder coatings from rejected parts. The ovens remove all organic materials from the fixtures and rejects but leave behind the inorganic pigments (usually titanium dioxide), which are generally removed with a high-pressure water spray.

Other ways to strip fixtures and rejects include the use of chemicals, molten salt, fluidized beds, and blasting media. You can also strip fixtures and rejects manually or just throw them away.

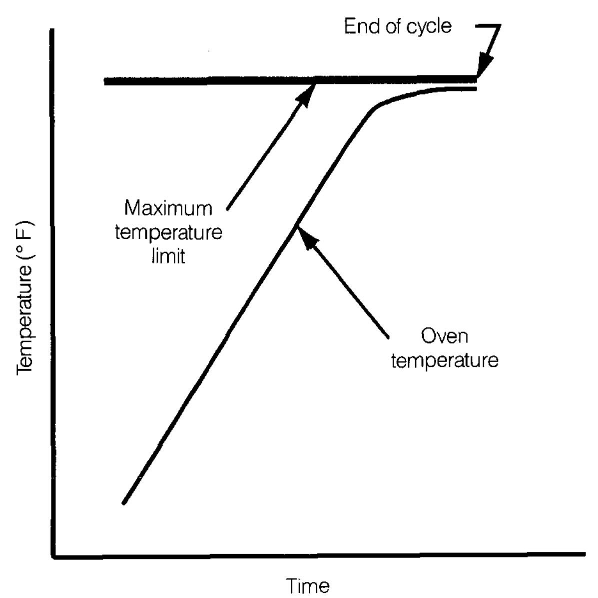
Each method has advantages and costs that you need to evaluate. Chemicals, for example, clean fixtures relatively fast and don't require additional cleaning steps. On the other hand, some powders aren't suitable for chemical stripping, and chemical waste disposal is an added cost and potential liability. Workers may also be exposed to the chemicals.

Molten-salt and fluidized-bed systems also offer fast cleaning with minimal secondary cleaning. Installation costs for these systems, however, are several times higher than they are for burn-off ovens. Media blasting is suitable for large, relatively flat surfaces, such as airplanes, but unsuitable for a large load of fixtures with small surfaces. Manual cleaning is labor intensive and unsuitable to high-volume production. Throwing fixtures and rejects away makes sense only when replacement costs are very low.

Burn-off ovens have proved to be an economical option for stripping fixtures and rejected parts. Although they take longer than some other stripping methods and often require a secondary cleaning step, emissions are quite low and the small amount of ash generated can usually go in the trash. With burn-off ovens, environmental impact is minimized and operator safety is maximized.

FIGURE 2

Fixed-setpoint fire detection systems spray water if the oven temperature exceeds the fixed maximum temperature limit.



Selecting the proper size and features for your application

Over the years, many improvements have been made in burn-off oven technology. Modern high-performance afterburners produce very low emissions, and control systems can sense the amount of vapor in the oven and control it at a safe level to prevent fires. It's now possible to remove large amounts of powder quickly and safely. Some ovens can even determine when the process is over and shut off automatically. These ovens run no longer than necessary to do the job.

To select the appropriate burn-off oven, however, you need to determine the correct size and appropriate features for your application.

Oven size. The oven must accommodate the largest pieces to be cleaned and the quantity of fixtures that will become coated on the line during the cleaning cycle. Cycle times generally run 2 to 4 hours, depending on the amount and type of powder on the fixtures and oven temperature. Allow an additional 30 minutes for loading, unloading, and washing. If 100 fixtures must be cleaned each hour, the oven should be capable of holding 250 to 450 pieces.

The oven must be large enough to allow spaces between fixtures for hot burner gases and cooling water spray to circulate. The ovenmaker should be able to help you select the correct size for your application. Computer-assisted design systems are useful for laying out geometrically complex parts.

It's generally more time and energy efficient to run large loads, rather than small loads, because of the additional time required for loading, heating, cooling, and unloading multiple loads. If extra hooks are available for production runs, a larger oven may be more economical than a smaller one.

Oven features. Important features for burn-off ovens include fire detection systems, cycle-time control, heating method, combustion chamber location, afterburner design, burner type, stack construction, wall construction, pressure-relief door design, and processing speed.

Fire detection systems. This is the most important burn-off oven feature. The ovens don't really burn off the coating because this would cause the fixtures to get extremely hot and warp. Instead, the ovens thermally decompose powder into a combustible vapor in a low-oxygen atmosphere to inhibit combustion and then destroy this vapor in an afterburner. If vapor is produced too rapidly, an ignition may occur in the oven and cause release of smoke into the shop. Too much vapor can also overload the afterburner and cause smoke to come out of the exhaust stack. Even a very large capacity afterburner can be overloaded if a fire occurs in the oven.

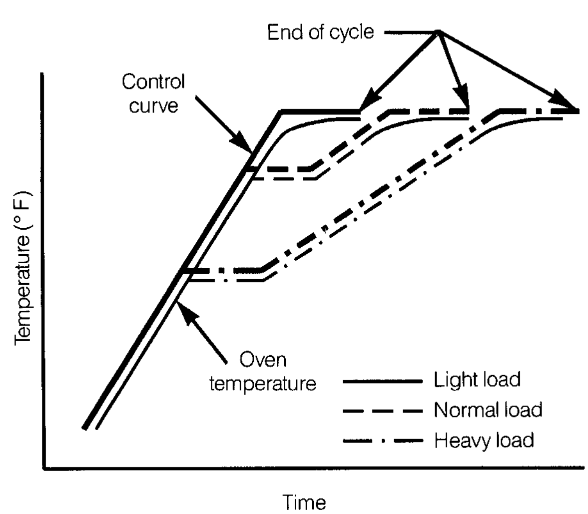
Fire detection systems fall into three groups: (1) fixed setpoint, (2) variable setpoint, and (3) dynamic response.

Fixed setpoint. This system (see Figure 2) allows the combustible vapor to ignite, which drives the oven temperature above the maximum temperature setting. A temperature switch turns on water sprays to put out the fire. This method allows a fire to start, but once the fire occurs, it can be difficult to control and smoke may overload the afterburner or leak out of the doors.

Variable setpoint. This system, shown in Figure 3, is a refinement of the fixed-setpoint system in that a ramp-and-soak type controller increases the oven temperature setting over a fixed time (ramp) until the final processing temperature is reached. It then holds that tempera-

FIGURE 3

Variable-setpoint fire detection systems spray water if the oven temperature exceeds operator-selected water-spray control curve (profile).



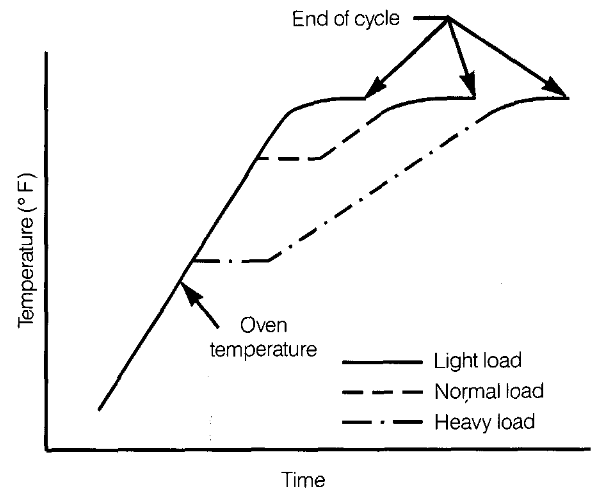
ture for a predetermined time (soak) to complete the decomposition.

This ramp-and-soak profile is usually programmed by an operator or selected from a menu that includes a number of profiles. The operator must estimate the amount of combustible material in the load, which is difficult to do. Formulas aren't available to tell the operator how fast to ramp and how long to soak. If the wrong profile is selected, the temperature may increase too rapidly, causing a fire, or the oven may shut off too soon, allowing smoke to come out of the stack. Because this system doesn't monitor the stack temperature, a stack fire is also possible.

Dynamic response. Figure 4 shows a dynamic-response system. These systems actually monitor the combustible vapor concentration in the oven and control it at a safe level. They respond to the load and don't require the operator to make any decisions. If the load doesn't produce excessive vapor, cooling doesn't occur. As a result, cycle times are as short as possible. Two dynamic response systems are available: Controlled Pyrolysis[2] and the more recent Rate of Change Control[3].

FIGURE 4

Dynamic-response fire detection systems automatically spray water to control oven temperature at the level that produces a safe amount of combustible vapor without operator-selected control curves.



Most fire detection systems use water sprays for cooling. The fine droplets in the spray turn to steam, cooling the fixtures and slowing vapor production. These are usually fine misting sprays that can be easily clogged with contaminants in the pipe. Consequently, a backup system with a large-diameter nozzle that won't become clogged should be used. The primary burner should automatically shut off to stop the process if the water sprays fail to cool the load.

Cycle-time control. There are three methods commonly used to control cycle time: (1) batch, (2) ramp-and-soak, and (3) automatic cycle.

Batch. In this basic cycle-time method the operator uses a batch timer to select the length of time the oven will run. This method requires a skilled operator to estimate the required cycle time. If the operator underestimates the cycle time required to process the load, the oven will shut off while it's processing. This can result in partially cleaned fixtures and possibly emission of smoke from the exhaust stack. To avoid this, operators often add extra time to the normal cycle, which results. in wasted time and fuel.

Ramp-and-soak. Ramp-and-soak controllers often use the ramp plus the soak time as a cycle timer. This method also requires a skilled operator to examine the load and select the appropriate oven profile. It's still possible for the oven to shut off while it's processing vapor if the operator underestimates the soak time.

Automatic cycle. Dynamic response systems can sense when the oven is no longer producing combustible vapor and when the oven is up to the selected temperature. This means that the oven can be shut off without releasing smoke to the atmosphere. Because burn-off ovens have cool spots—usually in the floor near the front door—a second thermocouple in the coolest part of the oven will assure that parts are uniformly heated before the oven shuts off. This allows the oven to automatically adjust the cycle time to suit the load and remove the possibility of operator error.

Heating method. Most burn-off ovens are heated by gas or oil burners, rather than electric heaters. Burners produce low-oxygen gases to help prevent oven fires, are less expensive to operate because gas costs less than electricity, and make superior afterburners because the vapor must pass directly through the burner flame.

Most ovens have the primary, or oven-heating, burners in the bottom of the processing chamber and the secondary burners, or afterburners, on the top (see Figure 5). This heating method grew out of incinerator technology. It's the fastest way to burn materials in an oven and the least expensive oven to construct.

Some ovens have their primary combustion chambers in the bottom rear of the processing chamber and throw hot gases under the cart or baskets holding the fixtures. Some have the combustion chamber under the cart or along one or both sides to improve the distribution of heat to all parts of the oven.

Most ovens measure and control temperature at the top of the processing chamber; however, it may be much hotter near the combustion chamber outlet. Temperatures in this hot zone can reach 1,200°F or more (see Figure 5). This can cause overheating of parts placed too close to the combustion chamber in an oven heated from the bottom.

Aluminum and other temperature-sensitive parts should be placed away from the combustion chamber outlet. Heavy coatings can drip into bottom-fired chambers, which increases the possibility of fires. Because hot air rises, much of it may escape out of the top-mounted afterburner without completely heating the load.

Another way of heating these ovens is by introducing heat in the top of the oven and removing cooler gases and combustible vapors from the bottom (see Figure 6). This top-to-bottom heating method[4] has some advantages over bottom-fired designs.

For one, the hottest spot in the oven is at the top where the controlling thermocouple is located. The hottest spot in a bottom-fired oven is where the fire comes out of the combustion chamber. This is an important consideration when stripping temperature-sensitive parts, such as aluminum. Even steel will warp and deteriorate if it gets too hot, however.

In addition, in top-to-bottom heating the hot, low-density gases spread out over the length and width of the oven, which results in uniform temperature distribution. In bottom-fired ovens the hot gases often rise to the top and exit through the afterburner before they reach all the parts in the oven. Top-to-bottom heating also traps the heat in the oven. This heat must then pass through the load before exiting from the bottom, which increases load-heating efficiency.

Combustion chamber location. Combustion chambers may be located inside or outside the oven. They may be on a rear or side wall, behind or under the cart. Inside chambers are often damaged by careless loading or by falling parts; outside chambers can't be damaged this way. However, outside chambers should be enclosed in sheet metal to prevent damage to the chambers and to protect personnel from the hot surface.

Afterburner design. You need to be reasonably sure that the oven you are considering will meet current and future air quality regulations. The most important device for low emissions is the afterburner.

As mentioned previously, the organic materials in powder coatings, such as resins, curing agents, and organic pigments, thermally decompose into hydrocarbon compounds in the oven. Because this vapor, or smoke, shouldn't be discharged to the atmosphere, it's burned in the afterburner to produce primarily carbon dioxide and water vapor.

An afterburner is an insulated chamber where the oven vapor is mixed with air and heated to a temperature sufficient to destroy organic materials. Generally, higher temperatures and longer dwell times give lower emissions. Elements such as chlorine in thermoplastic polyvinyl chloride and fluorine in thermoplastic fluoropolymers aren't destroyed in the afterburner and pass into the atmosphere. Usually, the levels are below allowable standards; however, you should verify this with your state air quality agency.

You can improve the performance of the afterburner by using a temperature controller and an additional gas

FIGURE 5

A burn-off oven with rear-fired bottom heating and internal chambers

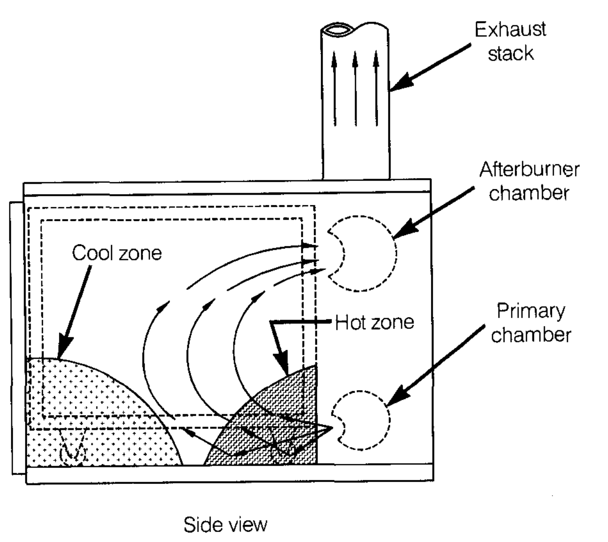
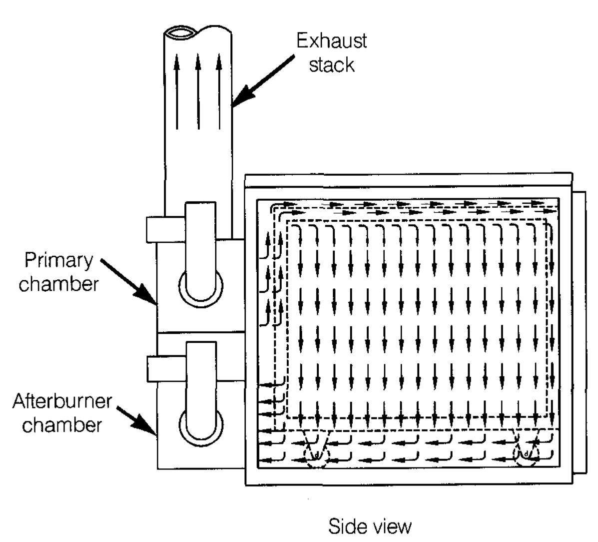
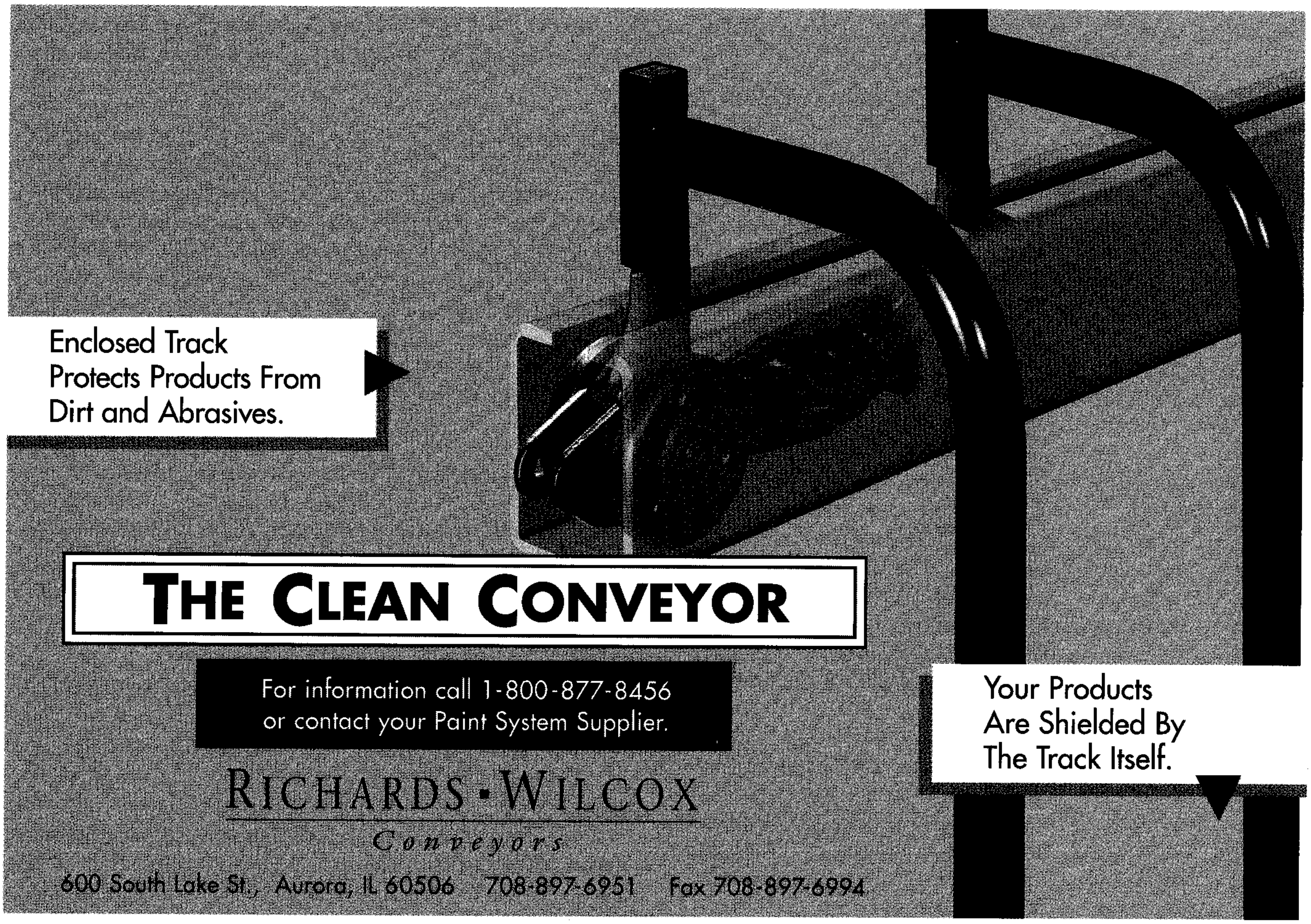


FIGURE 6

A burn-off oven with top-to-bottom heating and external chambers





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valve or modulating gas valve to increase the gas flow when the afterburner temperature is below 1,500°F. This allows the afterburner to heat up rapidly and maintain the minimum operating temperature.

Most states require a minimum afterburner temperature of 1,400°F as measured at the ½-second point of the afterburner. This gives the vapor at least a ½-second dwell time at the required temperature. Some states require 1,500°F; others require that the afterburner reach 1,400°F within 15 minutes. Because air quality regulations are becoming more stringent, it'll pay to buy a high-performance afterburner.

Afterburner processing capacity should handle the largest possible vapor load from the oven; otherwise, smoke will be emitted from the stack. Dynamic-response systems automatically limit the oven processing rate to within the afterburner capacity. Other systems may require an afterburner with greater capacity to handle sudden large vapor loads. Larger afterburners use more fuel and cost more to operate than smaller afterburners.

Another good feature for a burn-off oven is a cool-down circuit that turns on the water sprays to cool the load and prevent smoke from going up the stack in the event of an afterburner failure. This circuit should have a temperature switch that turns the water off when the oven is cool to prevent oven flooding.

Burner type. Burners are available in many different designs and materials. The most common burners are fabricated from light-gauge sheet metal. This incinerator-type burner has been used in many ovens over the years and is suitable for light-duty primary and secondary chambers where the steel temperature doesn't exceed about 1,000°F. They can be used at temperatures higher than that, but the expected service life of the burner will be shortened.

Ovens with high firing rates and elevated chamber temperatures should use heavy-gauge sheet metal or cast iron burners with alloy steel or refractory firing tubes. These industrial-duty burners have greater output, better air control, and lower emissions than the light-duty incinerator-type burners often used in burn-off ovens.

There are two ways to control oven temperature with the primary burner. First, the burner may be turned on and off at setpoint, requiring it to restart many times during a run. A second way is to leave the burner on all the time and reduce and increase the gas flow at setpoint. This high-low firing method reduces the number of lighting failures and wear on the burner components.

Stack construction. Insulated exhaust stack is necessary to discharge the hot gas from the afterburner into the atmosphere. The stack should end at least 2 feet above the roof. Local codes and NFPA standards may require it to be higher than that. The ovenmaker should be able to help you layout the stack for your installation.

Exhaust stack comes in two basic forms: heavy steel pipe with hard refractory lining or light-gauge steel with ceramic fiber lining. The heavy refractory type requires a crane to set it in place. It's self-supporting. The light-gauge steel stack is usually available in 36-inch-long sections that can be assembled by two people. Hangers or some other means must be used to support tall stacks and horizontal runs. Lightweight stack is available with a galvanized or stainless steel shell. Stainless steel lasts much longer than galvanized steel.

Wall construction. Most ovens have a structural steel frame and sheet steel walls. Ovenmakers have walls in standard thicknesses ranging from 16 gauge (about 1/16-inch thick) to 12 gauge (about 7/64-inch thick). Generally, heavy-gauge steel withstands attacks by water and corrosive substances better than light-gauge steel.

The atmosphere inside burn-off ovens is hostile. Extreme temperatures, water sprays, and organic or hydrochloric acid formed from the decomposing powder can damage the oven walls, which may be expensive to repair. When the walls are protected properly, the oven will last for many years. Usually, a coating ranging from paint to asphalt mastic protects the inside surface of the steel shell. A vapor barrier that prevents corrosive vapors from condensing on the walls provides additional protection.

The coating and vapor barrier must be insulated from the oven heat. Usually, 2 to 3 inches of mineral wool is used. Most manufacturers add rigid board or high-temperature ceramic fiber (¼- to 1-inch thick) to the inside surface to provide additional heat retention and to protect the mineral wool from high temperatures. The board loses its strength after exposure to oven temperatures, and fixtures easily tear the ceramic fiber when the cart is moved. Because insulation can be easily damaged, it's a good idea to line the inside wall with expanded steel or perforated aluminized steel sheet. If the insulation is ever damaged during operation, it should be repaired immediately to prevent damage to the vapor barrier and protective coating.

Pressure-relief door design. The NFPA requires that burn-off ovens have a means to relieve pressure from the oven in the event of an ignition[5]. These devices may be in the form of a spring-loaded front door or a gravity-loaded top door. The top door has the advantage of opening as far as necessary to relieve pressure and then closing automatically by gravity to keep smoke in the oven and oxygen out. The hot gases, moreover, are directed away from the operator. The opening area should be 1 square foot for each 15 cubic feet of oven volume[6].

Processing speed. Ovenmakers make many claims about cycle times for their ovens. Low numbers—like 1 to 2 hours—will probably be for loads with very small

amounts of combustible material. In an actual production environment, the cycle times may be longer than that. You should contact customers with applications similar to yours to verify that cycle times are as short as the ovenmaker claims. To get a good estimate of cycle times, ship a full load of fixtures to the ovenmaker for testing.

Sometimes, you can achieve fast cycle times by overheating parts located in the bottom of the cart or by operating without a fire detection system, which may create a hazard (remember, nothing is faster than a fire).

Some manufacturers will offer large-capacity afterburners to increase the processing speed of their ovens. If the afterburner is sized adequately to handle the vapor load from the oven, as discussed earlier, increasing the capacity of the afterburner won't speed up the oven. Generally, you can achieve short cycle times by increasing the burner gas inputs. Comparing manufacturer's actual burner input—not rated input—will help you determine relative processing rates.

Some final words about burn-off ovens

A burn-off oven removes all materials that decompose at an operating temperature from 600°F to 900°F. The remaining material is ash formed from the nonvolatile organic materials and inorganic pigments, such as titanium dioxide. The ash formed from organic materials easily falls off the fixtures when they are brushed or tapped.

Inorganic pigments require a different approach, such as washing with high-pressure water spray or quenching with water. Generally, fixtures coated with light colors are more difficult to clean than those coated with dark colors. Send sample fixtures to the manufacturer for testing to determine the amount of secondary cleaning required.

When you buy your burn-off oven, you should also plan to install a wash station where the fixtures can be cleaned with a high-pressure washer. A wash station can take many forms but should include a floor drain or sump pump to handle the water and partitions or curtains to contain the spray. It should be located as close to the burn-off oven as possible. Transporting fixtures before washing them can leave pigment and ash all over the plant. In most cases, the wash water and solid materials can go down the sanitary-sewer drain; however, you should verify this with your local water-treatment authority. Titanium dioxide is nonhazardous and is used in many foods. Check your powder coatings manufacturer's material safety data sheet for heavy metals and other inorganic materials. Systems are available that collect and recycle the wash water if required.

Many states require you to get an air permit for a burn-off oven. Some states require a permit to construct before the oven is delivered. In some states, burn-off ovens are exempt from permits; however, the air quality agency should be notified of the installation. The buyer is responsible for the permit application, but the ovenmaker should provide all the technical information necessary to complete the application, including expected emission rates. Some manufacturers provide this service free; others charge a fee. It's a good idea to get a permit before you buy the oven so that you won't buy an oven you can't operate.

Making the right decisions when selecting a burn-off oven is the same as buying any other equipment. To get the right one for the job, you need to become knowledgeable about the product, determine your current and future requirements, and shop for the best service and value. **PC**

Endnotes

1. NFPA Bulletin 33.
2. Trademark of Pollution Control Products, Dallas.
3. Author holds patent.
4. Top/Down Heating, author holds patent.
5. NFPA Bulletin 86.
6. Ibid.

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