INDUSTRIAL DEGREASING & CLEANING 101

VARIABLES TO CONSIDER WHEN SPECIFYING DEGREASING PRODUCTS AND HOW TO CHOOSE THE OPTIMAL SOLUTION FOR YOUR OPERATION.

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Variables to consider when specifying degreasing products — and how to choose the optimal solution for your operation

INTRODUCTION

Removing dirt, grime, grease, oils and even interim production chemicals from equipment, tools and substrates is a frequent, widespread as well as highly diverse activity throughout the manufacturing, production and utility sectors, as well as in nearly all areas of industry. Indeed, some types of procedures are universally common to many types of operations—cleaning motors before maintenance or repair, for example—while we also see many more highly specific, highly customized efforts developed ad hoc to meet the specialized needs of the individual industry and application.

To accomplish any degreasing task—commonplace or specialized—users often employ not only products literally called "degreasers"—which themselves can vary considerably in chemistries, performance and relative regulatory burden among different brands and formulas—but also products called "brake cleaners," "citrus cleaners," mineral oil-based cleaners and many other options. Each of these choices have their pros and cons—but which is the best choice for your operation? This white paper will help the reader to better understand the various properties desirable in performing general and specialized degreasing functions; the ingredients that help deliver these actions; the regulatory, safety and other ramifications to consider, and more.

Degreasing — an urgent and vital operation, broadly used throughout industry

Degreasing is a universal function in nearly every kind of industrial operation, including automotive, aerospace, oil & gas, power generation, light and heavy manufacturing, steel production, telecommunications and many more. In these and other industries, production and moving equipment of all kinds often attracts significant volumes of dirt, grease and grime in operation and must be cleaned before examination and repairs can begin, or even proactively cleaned periodically just for their own sake as part of regular preventive maintenance to optimize everyday performance. Just as a few examples, this might include removing baked-in coal dust from steel electrical boxes in a coal-fired generating plant, cleaning a motor that has "grown fur" due to the relentless dust and oil in the surrounding air, or periodically removing the inevitable residue from plastic or steel molds and dies, maintaining release efficacy as well as helping to reduce potential pitting and optimizing the quality of the finished part.

In addition to these maintenance functions, degreasing is often utilized in the workflow of a production process, such as preparing a part for painting or assembly. For example, after some machining processes, flammable oils must be removed from substrates before a welding or similar next step process is begun. Parts and equipment are often treated with corrosion inhibiting chemicals while in storage which must then be thoroughly removed in order to get the items safely ready for use. And, often, excess thread locker, primer or other enabling chemicals must be removed before additional production steps can commence.

We also see some highly creative and specialized applications of degreasing, as operators endeavor to optimize the workflow for a very specific application. These include specific workflows created for unique tasks necessary to achieve production goals. As just a couple of examples, we have seen degreasing products, in the telecommunications industry, effectively enabling the transfer of live copper cable from bulk spools; and, in a very different application, "super prepare" deeply residue-free substrates for extended, long lasting, decade-plus adhesion of identification materials to a product surface.

Degreasing products can deliver a potentially wide range of properties

No matter what the application, no matter what the industry, proactive local and corporate-level operations managers, environmental health and safety (EHS) professionals, technicians, purchasing agents and other stakeholders will work to identify the optimum mix of properties in the degreasing products they specify. And, often, there are trade-offs that must be weighed to identify the overall most effective product for the particular operation. These potential properties to consider are often specified on the product Safety Data Sheet (SDS) and/or Technical Data Sheet (TDS) and include:

Non-Flammability

With many factories operating heavy machinery like welding or grinding equipment that can generate sparks, or having adjacent furnaces or other open flame sources, non-flammable chemicals are often mandatory and the primary criteria when specifying a product in many operations. In addition to the obvious safety considerations, using true nonflammable products can often enable operations to degrease equipment on-site without necessitating taking it off the line and to the shop, reducing downtime and increasing productivity. Do note, however, that "nonflammable" and "nonconductive" are different properties and should be specified and examined accordingly.

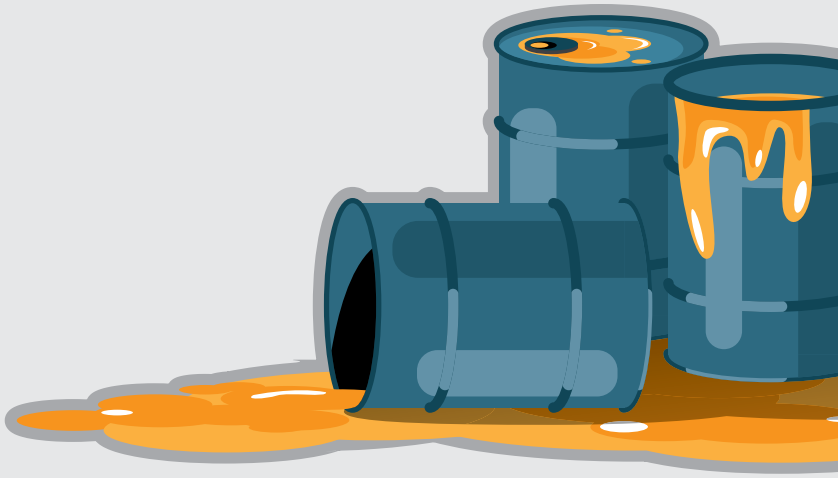
Note also that there are actually a number of levels to the concept of nonflammability to consider, and even those products that are labeled "nonflammable" might still have opportunity for combustion and related hazards under the right circumstances.

For example, some products deemed nonflammable contain alcohol, and are nonflammable—but often only after the alcohol evaporates away. Others are nonflammable, but run the risk of remaining residues, when contacted by high temperatures such as a welding torch, potentially generating poisonous gases.

Another concept to understand when considering the relative flammability of different product options is flashpoint—an often misunderstood concept. Flashpoint is NOT a point at which a product can spontaneously ignite, rather, it is the temperature at which an otherwise nonflammable product becomes flammable and can potentially ignite in the presence of flame. However, ignoring the flashpoint can still be very dangerous, since a "nonflammable" product used in a very hot environment could theoretically become as flammable as a flammable product, becoming combustible and contributing to a fire. That fact must be taken into account, with the proper precautions taken, in order to ensure the safety of personnel and equipment.

Toxicity and Environmental Impacts

Understanding the safety, health and environmental profile of the chosen degreasing solution is vital in a number of ways. First and foremost, the more potentially hazardous a chemical formulation is, the greater the chance for incident and danger to people. In addition to human safety concerns, this also opens up liability and morale issues that can be instigated by an incident or misuse, as well as potentially regulatory issues related to local, regional, state, federal and international authorities—issues that are always evolving.



To offer optimum protection, formal programs must be created commensurate with the risk—and that means providing personal protection equipment (PPE) such as gloves, goggles and suits and training in and otherwise ensuring their safe and effective usage, as well as perhaps modifying spaces or providing greater ventilation. It means perhaps monitoring and limiting exposure for every individual employee as per the relevant regulation limits. All of that takes resources and time away from productive work. Further, with many chemicals highly regulated, there may be the need to create formal compliance and surety programs as well as the ever-present threat of fines and regulatory actions—not to mention oversight by insurance companies and other stakeholders. Negligence claims are always a possibility even when everything is done "right." For these reasons, many operations look to specify the lowest impact product possible that will do the job, and place the safety factor high in the "give and take" balance of properties. More details about the regulatory profile surrounding commonly used degreasing products—including personnel issues and environmental VOC issues—are included later in this document.

Cleaning Effectiveness

The relative speed and efficacy of cleaning is a vital aspect of the specifying decision. Clearly, the faster and more effectively a product cleans, the less "elbow grease," wiping, scrubbing, re-applying and overall labor time and effort is needed, and the higher the worker efficiency that can be achieved. Further, the more thorough the cleaning job that is done, the more successful the next step in the process can be, whether it's a maintenance or production related workflow.

Of course, relative cleaning strength can be highly task dependent, with variables including the substrate, the viscosity and consistency of the substance to be removed, the surrounding environment, the skill and dedication of the technician, and more. We always suggest that operators test a number of degreasing products side by side in the actual application to see what works best for them in the real world.

That said, there are some more universal, objective gauges to help narrow the playing field. One of these is the relative Kauri-butanol (Kb) value. The higher the Kb value, the more aggressive the solvent is in its ability to dissolve certain materials. Kb value is a standardized measure of solvent power and is established through an ASTM International standardized test, ASTM D1133. Somewhat arbitrarily, Kb values of about 80 and above are considered fairly effective, but the higher the number the better the cleaning—in balance, of course, with other desirable properties such as relative toxicity, flammability, evaporability and others as discussed in this document.

In addition, we were recently acquainted with a perhaps more unusual measure of cleaning effectiveness, but one which was quite vital for the success of the specific application. This concerned a customer that was seeking to clean a metal substrate so deeply that an identifying decal applied to the clean, residue-free surface would adhere very securely. The way they measured this was to measure the pull-off-force needed to remove the decal, as measured in newtons. They had set 7 newtons as a challenging target level, and by way of interest, the product that we had suggested for the task—LPS Instant Super Degreaser 2.0—was shown to provide cleaning effectiveness that resulted in a newton rating of 10—some 40% better than the target.

One final word on cleaning effectiveness—be certain that the substrate you are looking to clean in your process is taken into account, as cleaning effectiveness can vary on whether the product is metal, plastic, composite, rubber or other material, and what type or mix of types thereof. In addition, some solvents can be rough on certain substrates, and weaken or damage them. All the more reason to test the actual product in your actual application for some real world performance metrics.

Relative speed and completeness of evaporation

Evaporation levels can mean different things in different applications and with different cleaning products. In some instances and with some products with lower Kb values, a slow evaporation/slow dry might be desirable, as the longer contact time could mean that the degreasing product stays in contact with the material longer and potentially provides deeper penetration and more robust dissolving action, although this can vary. The flip side of this is a product that is fast evaporating but low in cleaning effectiveness, so that it might evaporate before getting the job done and require multiple applications. Further, some cleaning products might tout that they don't evaporate completely, actually leaving by design a protective coating behind that might be desirable in some applications.

Perhaps more frequently, operators look for an aggressively performing degreasing product with a fast "dry time"—one that evaporates quickly and completely. In this regard, the "holy grail" perhaps would be a product which removes all material quickly in one shot and then completely evaporates, avoiding the need for scrubbing away leftover material, rinsing or wiping away cleaning product residue afterwards, or "waiting and watching" for a lengthy period for the evaporation off the surface. This would allow the highest possible throughput and the cleanest surface for the next step in the workflow, such as safely welding, securely adhering a decal, or providing effective maintenance and repair to a part or piece of equipment.

Many variables might go into the speed and completeness of evaporation, including, by chemistry, the size of the product molecule, and, more practically, the substrate and material to be cleaned, as well as how the particular product is used. Again, once a handful of products are shortlisted, a comparison test in the facility under real world conditions might provide the best insights.

Relative Conductivity

Often, operators might need to clean live electrical equipment or an electrical box to remove contamination in the contacts that can impede performance or other issue. While shutting off power and/or removing the equipment to a shop might be the absolute safest option, it is not always practical. For this reason, many operators look for products that are nonconductive and so can be used on or near live energized equipment in operation. Manufacturers often provide ratings on their nonconductive products such as "Nonconductive up to XX,000 Volts," so operators should be sure to match the rating to their need. Of note, specialized products called "Contact Cleaners" are often specified in these applications, due to their high voltage limits. As always, there are tradeoffs, and all properties—such as relative cleaning effectiveness or safety/environmental performance—are often weighed in making the decision as to which type of product to deploy for optimum results. It should also be noted that relative flammability is a whole other issue, and users would likely want to doublecheck that the product is also appropriately nonflammable as well as appropriately nonconductive in case of an errant spark generated by the energized equipment during the cleaning process.

Product dispensing

Another issue, unrelated to the chemistry of the solvent itself, is whether or not the manufacturer, when providing an aerosol can, provides the addition of a "dump valve," "blast-off," "power blast" or similarly named higher volume, higher force spraying option. Many look for this technology as it can provide more product faster and with more kinetic force to help break up stubborn dirt. Often it allows a spraying from further away, due to relative safety or tight access, if this is of concern. Of course, there are trade-offs, such as—does more product dispensed mean more need for wiping or slower throughput? Is there a danger of excessive product waste in the hands of a less experienced user? Does a slow evaporating product lead to adjacent pooling/puddling? Again, these and other relevant questions can readily be answered by trying it in the specific application.

Product packaging

As suggested, the most common way of using degreasing products is with an aerosol can, with the product always at hand and "ready to go," and the container easily inventoried.

If available, bulk containers of a particular product might offer some upfront price advantages. We have seen options including gallon bottles, five gallon buckets and 55 gallon drums of product in this general category. However, these price considerations might be wholly or in part overridden by some of the inherent challenges of volume packaging. For example, the product must be otherwise pumped or moved to a third party "sure shot" spraying vessel, which takes labor time, might require donning specialized personal protective gear, lead to product spillage and waste and/or lead to contamination of the product. In addition, most technicians are not fans of any need for manual pumping, with the hand fatigue and potential carpal tunnel issues inherent with extensive trigger spraying motion.

In addition, with a fast evaporating bulk product, leaving the cover off for a period of time can lead to loss of product to the atmosphere, which can be not only wasteful but also impact product integrity—not often a problem with cans. Some products might also not be compatible with plastic containers and other ad hoc spraying vessels. Some find inventory an issue—such as the cost of storing

big drums. And the logistics of accessing them and moving them around a factory—necessitating a forklift and special handling—might be an issue as well.

On the plus side, bulk packaging options might help users avoid disposal costs and procedures related to aerosol cans, reduce the ease and threat of pilferage, as well as avoid any issues related to maintaining pressurized cans onsite, if any of these issues are of concern.

Relative total cost/value of product

Finally, as with any other product to be specified, relative cost must be weighed in any decision, balanced with all other relative factors to determine an overall cost/benefit story.

Certainly, upfront costs should be balanced with cleaning efficacy—at what point does a more costly product become a better value with each minute saved in labor of scrubbing and wiping and reapplying per piece, or a savings in waste or quality issues downstream? Proactive users often plug in their own computed labor costs and scrap rates, and compare appropriately.

Safety, health and environmental issues are also certainly vital—the cost of extra PPE precautions in lost throughput can quickly eat up any upfront savings—and the cost of one incident or law suit could potentially negate "years" of savings.

Another issue related to cost—one that is literally often "hidden" is the actual amount of useable product purchased with each can. One can't see the contents of course—and the size of the can itself is not a good indicator of how much useable product is provided. For example, the amount of propellent in the can—which of course is vital for dispensing the cleaning product but has no cleaning efficacy itself—can vary considerably. Products in this category might necessitate as little as 1% propellent or as much as 30% or more. So one should check the can or data sheets and use this information in any accurate cost/benefit analysis.

Many options in products and active ingredients to find the right balance

There are many classes of products used in the degreasing function, each with its own balance of the various properties discussed above.

A default product for this category is often some kind of brake cleaner—no matter what is being cleaned. Usually acetone-based, brake cleaner tends to be inexpensive and, while generally not effective enough to readily handle the toughest jobs, it does evaporate quickly and can make a good general cleaner for a wide variety of uses so many operations consider it "worth a try." Some find that a need for multiple applications and a higher level of scrubbing and labor time can somewhat override some of its price advantages. More importantly, however, brake cleaner is often highly flammable, so its use would be contraindicated in many operations; in addition, depending on the specific formulation, it can demonstrate a relatively high toxicity level.

Citrus cleaners are another type of lower performing general cleaners that may be adequate in some applications, often effective on light dust and dirt and some tars and adhesives, but falling short on heavier greases and oils. They also deliver flammability concerns, as well as leaving significant residue that requires an additional wiping step. Electrical cleaners are often nonconductive, but can be limited in their spray power and cleaning ability, so more aggressive cleaners that also provide nonconductive properties can be investigated. Paint thinner type products such as mineral spirits, xylene, toluene are sometimes employed, but are not usually suitable for tough industrial jobs, besides being highly flammable and causing inhalation concerns for the user.

If nonflammability is mandatory in the application, then halogenated solvents are the main group of products to consider. Halogens are a group of elements within the periodic table that are effective cleaners because they readily bond with other elements—indeed they are not found independently in nature—and due to their structure are also inherently nonflammable as well. Chlorine, bromine and fluorine are the most common halogens used in this class of product formulations. A particular halogenated solvent may therefore also be more specifically referred to as chlorinated, brominated or fluorinated depending on which of the individual halogens is used. Halogenated products generally also tick a number of other potentially desirable boxes, making for highly effective cleaners, as well as generally being fast drying.

Unfortunately, this class of products also bring with them varying levels of environmental concerns due to their release of volatile organic compounds (VOCs) implicated in ozone depletion. These can vary considerably product to product.

Further, halogens can also demonstrate some degree of target organ toxicity and other health hazards—and so bring with them an increasing need to supply and mandate personal protective equipment, limit exposure and monitor the regulatory environment, although this can vary considerably depending on the formulation. Indeed, there

are many well known chlorinated and other halogenated solvents that have become more heavily limited in use over the years due to potential health, safety and environmental concerns—with many products in the class often tagged as suspected carcinogens. Perchloroethylene—also called PERC or dry cleaning fluid—is one such molecule, and had been a valuable "go-to" for many years due to its outstanding cleaning ability, fast drying time and of course nonflammable nature. Today it is heavily regulated and is less commonly used in these formulations. Trichloroethylene, also known as TCE, is another high performing chlorinated solvent with similar health, safety and environmental concerns. 1-Bromopropane, also known as n-propyl bromide (nPB), is a "nonchlorinated" (brominated) halogenated solvent—it uses bromine instead of chlorine as its halogen to achieve nonflammability performance and so is rather a brominated halogenated solvent. Its high cleaning performance, favorable price point and believed low health, safety and environmental impact led many to adapt it to replace chlorinated solvents such as PERC, TCE, methylene chloride and 1,1,1 trichloroethane (TCA) in many applications, and it has been doing so for more than 20 years. More recently, evolving developments in toxicology research have led regulatory agencies to reevaluate earlier positions, and many organizations are taking a stronger look at if and how to make safest use of nPB-containing products.

Fortunately, innovative chemical engineers have been effective at changing balances of physical, chemical and biological properties by changing the position of atoms on the halogenated solvent molecule—these may be called trans isomers and cis isomers, for example, depending on which side of the molecule that different atoms are positioned. Further, they have discovered that mixes of properties can also be achieved—albeit by painstaking trial and error—by innovatively blending different chlorinated, brominated and fluorinated solvents in different ratios. Blends can potentially be developed that can reduce toxicity and environmental impacts, maintain or improve flammability profiles and optimize cleaning effectiveness. As an example, the LPS product ISD 2.0 mentioned above provides a mixture of trans-1,2-dichloroethylene (DCE), which provides very aggressive cleaning properties, along with Vertrel®, a fluorinated solvent that imparts overall nonflammability properties to the formulation, in a specific proprietary patented ratio. Together, the mixture provides a superior safety profile, and also provides an outstanding environmental profile, with lower VOC content and ozone depletion potential than most other halogenated solvent products reported.

Indeed, with the much wider portfolio and modern chemical engineering innovations that have been introduced to the category, the idea that "all" halogenated solvents or even "all" chlorinated solvents all act uniformly in a particular way has become outmoded. Each product should be looked at on its own merits to determine the best product for use. Further, this analysis is a moving target, with innovative manufacturers continually pushing the envelope, as well as new safety and environmental research providing insights into creating the most benign chemistries that deliver the best mix of performance as well.

Safety, health and environmental regulations and their potential impacts on degreasing functions

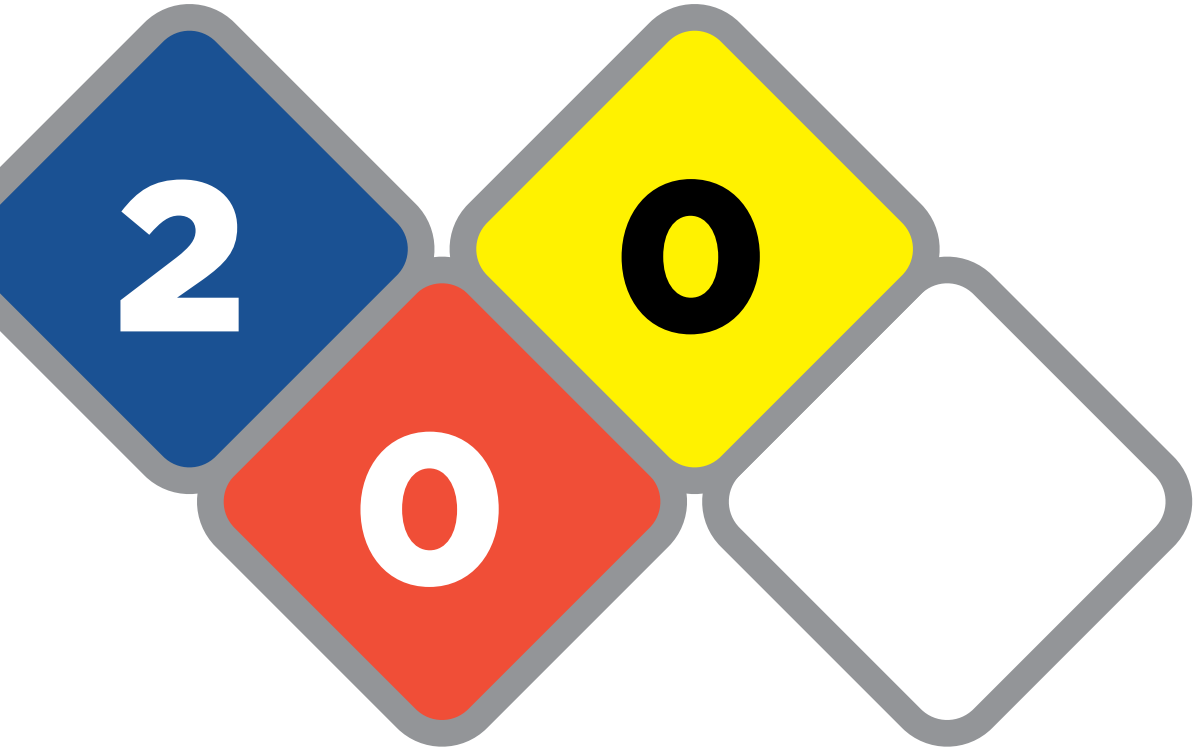
The handling and usage of industrial chemicals is dictated by a wide range of organizations including international, federal, regional, state and local governmental authorities, as well as, as a practical matter, policy dictates by individual industries, companies, organizations and even specific facilities. These are always evolving and keeping up can be a full time job. This section will describe some of the players and resources that may impact degreasing product decisions, but is obviously no substitute for individualized professional guidance.

In addition to usage and handling information that may be printed on the packaging of each product under consideration, the main source of user information in the United States is the mandatory Safety Data Sheets (SDS)—formerly called Material Safety Data Sheets or MSDS—for the product. The Occupational Safety and Health Administration (OSHA), an agency of the United States Department of Labor, requires that every chemical manufacturer provide these extremely detailed and informative documents to downstream users to communicate information on potential hazards of each product. The purpose of an SDS is to ensure that all workers who handle chemicals and other stakeholders have the information they need to safely use, handle and store them.

Safety Data Sheets are standardized documents presented in a specific, consistent, user-friendly 16-section format. They include information such as the properties of each chemical; the physical, health, and environmental health hazards; protective measures; and safety precautions for handling, storing, and transporting the chemical.

SDS sections include, but are not limited to:

- Manufacturer information, including emergency contact information
- Information on chemical ingredients and properties
- First-aid measures
- Fire-fighting measures
- Safe handling and storage procedures
- Exposure controls and limits
- Toxicological information includes routes of exposure
- Ecological information
- Disposal considerations
- Transport information



Section 8 includes some especially practical information, detailing the personal protective equipment that users must wear, as well as OSHA's Permissible Exposure Limits (PELs) for the chemical. This is expressed as a Time Weighted Average (TWA) based on an eight-hour workday and expressed in parts per million (ppm). Once the exposure limit has been exceeded, the individual may not be exposed to the chemical for the rest of the workday. Of course, proper use of PPE impacts the exposure. Resources on how to calculate this are available online.

Of note, the document is produced in alignment with the United Nation's Globally Harmonized System of Classification and Labeling of Chemicals (GHS), an internationally agreed-upon standard established to provide consistency for hazardous material classification and labeling schemes in use around the world.

The SDS may also refer to Volatile Organic Compounds impact of the chemical. VOCs are substances which can impact the breathable quality of indoor air as well as cause ozone-related issues and smog effects in the atmosphere, and so the need for PPE, ventilation and other guidelines can impact their usage. In the U.S. these are overseen by the United States Environmental Protection Agency (EPA) and can vary among the states. More than half of the 50 states currently have VOC regulations in place; VOC regulations issued by the South Coast Air Quality Management District in California and by the California Air Resources Board (CARB) are known as especially stringent. Indeed, regions like this that are very mountainous or otherwise have conditions conducive to "trapped air," smog and similar breathability concerns are often most proactive in this regard.

As noted, information concerning chemicals are often evolving. Efforts such as the Toxic Substances Control Act (TSCA) administered by the EPA regularly analyze new or already existing chemicals, leading to changes. Be sure to always have the latest version of your SDS.

In addition, it is important to understand that usage regulations can often differ depending on the function in which the product will be used—for example, some products are only allowed to be used in professional, industrial settings and only for high-value manufacturing and production purposes, where, presumably, their absence would lead to unacceptable economic impacts. In these cases, less high value areas—such as consumer/retail uses and maintenance uses would perhaps not be able to legally deploy these products and would need to adopt other solutions.

Trade and private associations with specialized knowledge of certain factors—such as fire protection and safety related groups—may provide additional granularity or guidelines to certain rules as well that may be helpful. Independent scientific organizations such as the American Conference of Governmental Industrial Hygienists (ACGIH) often provide information and resources that are valuable to creating, understanding and following safe usage standards. Industry associations and individual companies might have their own guidelines that further clarify or expand upon these rules; for example, aviation and automotive manufacturers often publish specifications for acceptable products and their usages.

CONCLUSION

While there are many players and details surrounding safe usage of degreasing products, developing a methodology for optimum deployment should be no more onerous than learning the safe usage and procedures surrounding any other type of industrial chemical, machinery, equipment or other vital industrial tool. As millions of degreaser users have found, the path forward is determined by common sense and good corporate stewardship—determine the mix of properties that are most important, investigate and comparison test products to find the most effective performers for your specific circumstances, and proactively ensure their safe and effective usage. Doing so is not difficult, and potentially, as performance and yields improve, driven by the implementation of superior tools, it can be extremely profitable and rewarding in productivity, cost-savings and morale alike.