Critical Cleaning Topics in NDT:
Understanding the factors that govern how effectively a part will be cleaned

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Abstract (approx. 100 to 150 words)
Surface cleaning is used in almost every manufacturing process. The system’s primary function is to remove unwanted contaminants off a substrate. Of course, this is a very broad definition as soils and substrates vary from industry to industry and the degree of cleaning can also differ. In the special case of NDT inspections efficient cleaning methods are required to ensure that contaminants and residues do not interfere or hide any cracks, putting the parts (or the equipment they are part of) in jeopardy.

Several factors must be considered, in order to establish a working cleaning operation. This includes the type of chemistry used, the equipment available, the type and numbers of rinses, the process parameters or individual specifications to be considered.

Choosing the correct cleaning method and applying it properly have a big influence on the process effectiveness and finally on the NDT inspection result. With a special focus on chemical cleaning, the present paper makes a contribution to understand the basic principles of typical contaminations and to choose the right cleaning method as basis for reliable NDT inspection results.

Keywords: NDT, non destructive testing, cleaning

Hard surface cleaning is used in almost every manufacturing process, the systems primary function is to remove unwanted contaminants off a substrate. This is a very broad definition as soils and substrates vary from industry to industry and the degree of cleaning can vary also.

For in-process or interim cleaning a rough cleaning to remove gross contaminants only may be needed before the part can go to the next processing step. In the case of NDT inspection a critical cleaning is required to ensure that foreign contaminants do not interfere or ‘hide’ any indications putting the parts or the equipment they are part of in jeopardy. In this paper we will explain what a cleaner needs to be composed of and what parameters need to be considered when choosing a cleaning process.

Several factors need to be considered when choosing how to establish a critical cleaning operation. These include they type of chemistry you will use, the equipment that is available or you will purchase, what type and what number of rinses will be included, the parameters you will run your system at, what compliances or approvals need to be met, and what can be coming down the road as the next generation in critical cleaning.

Choosing the correct chemistry has a big influence on how effective your cleaning operation will be, traditionally two types of cleaning operations were employed, solvent cleaning and aqueous alkaline cleaning. Solvents are very effective in removing organic contaminants such as oils and greases. The contaminants become dissolved in the solvent and re-deposition is rarely a problem. Solvents though are volatile meaning that care must be taken to prevent evaporation and with new tough environmental laws monitoring VOC and other limits, solvents are becoming difficult to use in large operations. Aqueous Alkaline cleaning employs a blend of alkaline builders like caustics, silicates and phosphates each having their plusses and minuses. Caustic provide strong alkaline characteristics, but can be very damaging to soft metals if not properly inhibited, silicates provide excellent alkalinity and
protection for soft metals, but are difficult to rinse off and in NDT operations silicates can interfere with inspections as the silicates have a tendency to accumulate in some indications if not aggressively removed in a rinse system. Phosphates provide some alkalinity, but have some environmental concerns and do not provide much alkalinity to maintain concentration of a cleaning bath. Most aqueous alkaline cleaners used in NDT inspection today are a blend of these three builders with an eye to minimize the use of each one. Wetting agents or surface tension reducing agents are used to allow the cleaner to undercut the soils and lift them off the substrate. Depending on the wetting agent chosen, the soil can be split out a soil allowing it to rise to the top to be skimmed off, or the soil can be emulsified into the body of the cleaner preventing any chance of re-deposition onto the part. As a general rule wetting agents that split out soils will be low foam and emulsifying wetting agents will be high foam. With new technologies being developed the rules are being rewritten and formulators are having a whole new field of choices allowing them to cater a product to a specific requirement.

Part of the decision process is knowing what type of equipment will be used to clean the part, three major cleaning processes exist and all have their plusses and minuses. Immersion cleaning is probably the most common method. This process allows the part to be in contact with the cleaner at all times and depending on the amount of agitation, soil removal can be quite effective. Agitation can be in the form of an external mixer, a recirculation of the cleaning solution or through educators to produce a turbulent environment within the cleaning tank. Ultrasonic’s are quite similar to immersion except that the agitation is achieved through high frequency sound waves. Cavitation bubbles created by a transducer impact with the contaminants adhering to the substrate, this action can also penetrate blind indications, and recesses, and can remove tightly adhering or embedded soils off solid surfaces. Ultrasonic cleaning can be used for a wide range of work pieces, shapes, sizes and materials, and may not require the part to be disassembled prior to cleaning. Spray cleaning is not commonly used as many parts that will be inspected have complex geographies and although spray systems provide a high degree of mechanical action to the cleaning process, they do not allow a high degree of coverage. In a spray chamber the cleaner maybe sprayed at PSI ranging from 10 to 100 and contact time on the part is limited and more importantly this process does not allow for effective cleaning of blind holes unless there is direct impingement of the spray on the blind hole.

How you choose to run your system will also determine how clean you parts will become. If solvents are used as the cleaning medium, they will be run as revived and at room temperature. Many solvents have flash points which limits the ability of the solvent to be heated to accelerate cleaning, also agitation is generally not recommended as this mixing can accelerate the evaporation of the solvent be increasing the surface area exposed to the air. When working with an aqueous based product there are more choices to be made including the concentration of the product and the temperature. Many of the aqueous products have a recommended operating range developed by the manufacturer; this is determined by how much active material is built into the product and the effectiveness of the raw materials used. When making up a cleaning bath a general rule of thumb is the higher the concentration the more effective the cleaning will be, but there are pit falls in this philosophy. Having a higher concentration means that there is more cleaning material, yes, but included in the cleaner is also the alkalinity sources like silicates. As mentioned before silicates are very good sources of alkalinity as well as very good inhibitor against attack on soft metals like aluminum, but if not properly rinsed they will leave a residue which will interfere with NDT inspection. With Aqueous cleaners you have the flexibility to run the system as elevated temperatures to accelerate the cleaning process. Most aqueous cleaners can be used at temperatures above 120F and depending on the composition, some can be used up to 180F. At extreme temperatures some wetting agents will come out of solution due to their cloud point. The
cloud point is the point at which the wetting agent is no longer completely soluble, precipitating as a second phase giving the fluid a cloudy appearance and ultimately leading to a complete separation of the wetting agent rendering it incapable of participating in the cleaning process. In some cases as the temperature is reduced the wetting agent will go back into solution, but there are wetting agents that will not re-assimilate back into the cleaning solution. 

Rinsing of a part after cleaning is as important as the cleaning process itself, improper rinsing can undo any good cleaning. In a proper cleaning system the soils are removed off the substrate, but as the part is removed from the cleaning bath there will be residue from the cleaner and inevitably some of the soils that were just removed. If this residue is allowed to remain on the part it will re-adhere and present problems when subsequent NDT inspections are performed. A proper rinse tank is one that allows rinsing of a part in a minimum amount of time after the cleaning process; ideally the rinse tank should be at an elevated temperature (100-120F). An ideal rinse system will be comprised of a primary tank right after the cleaning process and a subsequent rinse tank at ambient temperatures. All rinse tanks should be counter flowed with the final rinse tank being constantly fed by fresh water and the overflow being sent to the preceding tank and then overflow sent to the cleaning tank as make up water. If only one rinse tank can be utilized a fresh water spray can be built on top of the cleaning tank that will provide an initial rinse as the part leaves the cleaning tank removing a percentage of the soils while they are still hot and very mobile. The final rinse can be done with DI water to limit any contamination from a municipal supply. 

The work being done will also help determine which cleaner is best suited for your operation, many industrial bodies today have standards and compliances in place to aid in ensuring that an approved product can be used. These approvals are not specific to any one process or situation, but rather they are designed to cover a wide variety of operations so none are very specific in telling you how to use the products or what the product should or should not contain. ASNT typically deals with what effect the product will have on a substrate or what specific effect will the product have when exposed to a given set of conditions. SAE/AMS approval covers a variety of conditions that can exist and measures how the product will respond to these conditions. ASME are designed to address the specific conditions that are most commonly found in pressure vessels and boilers. ISO is an international organization for standards and does have some standards dealing with the control and monitoring of cleaning products. From an environmental standpoint, in North America we have been working under the guidelines of TSCA and DSL for many years, we are now being confronted by new standards from Europe under the title of REACH, which refers to the Registration, Evaluation, Authorization and Restriction of Chemical substances. The European law went into effect in June 2007 and as they are in some cases more restrictive than either TSCA of DSL some companies are now requiring to compliance to these newer more difficult standards. 

Most of what we discuss so far was cleaning concepts for solvents and aqueous alkaline, but there are a few new technologies being investigated by companies as alternatives to the traditional processes. Supercritical CO2 or dry ice blasting is a technology of interest as it leaves no residue, is non-hazardous, easy to use, and has a low capital investment, but what is not clear so far is if it is robust enough to handle heavy soils. Investigation continues to determine how wide spread this technology can be. Varo Degreasing with n-Propyl Bromide has been tested as a direct replacement for use in vapor degreasing operations. The material is very effective in removing soils, but hazards to humans have not been minimized. N-Proply Bromide is still very volatile and has been identified as a neurotoxin for humans and a potential carcinogen in animals. What companies are focusing on are completely closed loop vapor degreasing systems which prevent any release of solvent into the environment. These
processes have been shown to be very effective in containing the solvent and producing clean parts. Biotechnology has been employed to introduce ‘bugs’ that will consume oils and other contaminants generated in a cleaning process without destroying the cleaning power of an aqueous system. Some systems that clean with only high pressure water are being evaluated; this system utilizes the impingement of water on the part to remove any contaminants. The use of an abrasive wiping media is also utilized; this is effective, but very labor intensive and not suited to a large volume of parts. If the media is not carefully chosen they can leave a residue which can hide indications.

The methods discussed here are for what is considered light contaminants, when dealing with heavy duty soils such as those experienced on the hot end of engines a completely different set of cleaning rules exist include the use of heavy duty caustics and strong oxidizing agents.

Cleaning does not only occur prior to inspection, but also as part of the inspection process. Removal of excess penetrant must take place prior to application of the developer and inspection under black light. When following Method C, after the penetrant has been applied to a part it is necessary to remove the excess to effectively identify any discontinuities under black light. The removal of excess penetrant is commonly done using solvents, commodity materials like Acetone are effective, but due to regulations, health and environmental laws and product characteristic such as flammability common solvents are not always the best choice. Alternative solvents have been identified that will remove the excess penetrant just as effective, but provide a greater degree of worker and environmental safety. Materials such as petroleum distillates will solubilize the penetrant on the surface without pulling it out of the indication; these solvents have high flash points and very good solubility. They do not volatilize as fast as acetone, but they do evaporate and leave no residue. Isopropyl alcohol is also used, this solvent is not a good in removing the penetrant and it does not evaporate as rapidly, but it has very good environmental profiles. Heptane is a material that encompasses the benefits of high solubility, fast evaporation and good environmental profiles. Heptane will very effectively remove excess penetrant leaving a part that is ready for the developer as there will be no residue on the part to interfere with processing. Heptane has no systemic effects and has a flash point of 25°F, although still low, it is much higher than other solvents. Recent rulings at an ASTM 1417 National meeting will no longer allow the use of commodity solvents to remove excess penetrants, only solvents approved under AMS 2644 can be used and furthermore it is recommended that higher flash point material be used to increase the safety of the cleaning process.

Other technologies exist and are being evaluated as a replacement for aqueous alkaline cleaning and solvent cleaning, but to date no technology has gathered a significant portion of the market. Aqueous cleaning does have it downsides, it needs a large footprint to function, it is costly to run and it generates waste that needs to be treated, but with the proper attention paid to factors outlined in this paper aqueous cleaning can be very effective in removing contaminants and produce a part that will be ready for NDT inspections without the fear that discontinuities and indications may be masked by un-removed soils or cleaner residue.