eBook

Cleaning & Cleanliness for Oxygen Service:

Best practices for maintaining equipment safety

The Importance of Oxygen Cleaning

Oxygen is one of the most widely used gases in a variety of industrial applications and environments. Because oxygen is a highly reactive gas, proper cleaning and cleanliness control are crucial to safe handling. Reducing risk of combustion and ignition hazards is vital to operating high-pressure oxygen equipment.

Haskel developed the following recommended guidelines for oxygen cleaning best practices, pulling knowledge from US MIL-STD-1330D standards, UK DEF STAN 68-278 standards, and QAD-154 standards. By following these best practices and maintaining proper oxygen cleanliness, organizations can reduce risk and ensure safer procedures.

Definitions: Oxygen Cleaning vs. Oxygen Cleanliness

Oxygen cleaning is a checmical cleaning process used to remove contaminants from any products intended for use with industrial oxygen. Though ignition of contaminants such as particles, even some metals, or hydrocarbons, can occur for a variety of reasons, removal of these contaminants reduces the possibility of auto-ignition and the likelihood of a disaster.

Oxygen cleanliness is the complete, consistent removal of contaminants from a part or component. The preset standard may differ, but filtration of cleaning solutions and proper rinsing after cleaning are critical to the process.

Cleanliness level requirements must meet those outlined in the Institute for Environmental Sciences and Technology document IEST-STD-CC1246D. Cleanroom cleanliness is essential because a clean room provides for airborne particulate control during cleaning, drying and packaging.

Cleaning Effectiveness:

Following US Navy Certified Protocols, like those available through Haskel International, is important. However there are influences that must be taken into consideration in each unique instance where oxygen cleaning is required:

- The chemical nature of contaminants
- The configuration and complexity of the parts to be cleaned
- The processing parameters required for the cleaning operation, such as temperature, concentration of cleaning agents, ultrasonic energy
- The details cleaning procedures

Contaminants:

Contaminants are solids or liquids that are generated during the manufacturing process or deposited from surrounding environments. They are typically categorized as:

Organic

- VOC compounds
- Hydrocarbon-based greases and oils

Inorganics

- Nitrates
- Phosphates
- Water-based detergents and cutting oils
- Acids/solvents

Particulate

- Particles, lint and fibers
- Dust, weld slag

Cleaning Best Practices

From proper cleaning equipment to recommended cleaning solutions, following best practices during oxygen cleaning improves results and overall cleanliness in applications that use high-pressure or industrial oxygen. The following outline detail recommendations for cleaning solutions:

Required Equipment:

- Pre-clean parts washer or immersion tank
- Ultra-sonic cleaning tank with a re-circulating system, filter, and associated cascade rinse tanks
- Equipment for drying oxygen clean parts
- Cleanliness Level Evaluation Equipment - including filtering device, microscope, balance, fluid contamination analysis kit, and UV lamp

Materials and Solvents:

- **MIL-DTL-24800** Cleaning Compound - Aqueous - Oxygen Systems Components (NOC)
- **MIL-P-27401** Nitrogen Grade B or C, filtered through a 3-micrometer filter, regulated to 30 psig, dry
- **MIL-STD-1330D** Standard practice for precision cleaning and testing of shipboard oxygen, helium, helium-oxygen, nitrogen, and hydrogen systems. (Water grade A, B, and C)
- **O-S-642** Tri-basic sodium phosphate (DAP anhydrous type 1), alternative aqueous cleaning solution, Type I, Type II, or equal. Type II is recommended because it is less susceptible to preciptiation. Any NVR analysis conducted will utilize CFC-113 or HCFC-225G

Commerical Cleaning Agents:

The commercial solvents listed below are acceptable for pre-cleaning. Other cleaners outside this list may be used if they are not chlorinated solvents.

- Octagon - OCC/NOC water-based cleaner (per MIL-DTL-24800)
- PF-WB water-based cleaner
- Turco 4215 water-based cleaner
- Daraclearn 282 low foam, all-purpose alkaline water-based cleaner
- Castro Kleen 3652 water-based cleaner (for immersion cleaning only)
- HelCat water-based cleaner
- GP-Extra water-based cleaner
- Techclean water-based cleaner
- Chemtech 7796 water-based cleaner (for immersion cleaning only)
- Chemtech 779-NWL-V water-based cleaner (for immersion cleaning only)
- Carroll - Blue Gold aqueous alkaline cleaner for ferrous and non-ferrous metals (used only with customer permission)
- DAP TSP aqueous cleaner, alternate for OCC/NOC

Safety Precautions

Oxygen cleaning procedures can have several risks, but the solutions used in these processes also have inherent dangers. Use the following safety precautions when performing oxygen cleaning sevices:

Dangerous Contact with Aqueous Alkaline Cleaning Solution:

- Skin contact with aqueous alkaline cleaning solution such as NOC will result in irritation and chemical burns. Wear protective clothing constructed of neoprene or other penetration-resistant material.
- Eye contact with cleaning solution could result in chemical burns. Wear chemical worker's goggles for all operations with potential eye contact with cleaning solution.
- Over-exposure to mists or vapors from cleaning solutions may result in sneexing, coughing, respiratory system irritation, and possible chemical burns and subsequent edema in the upper airways.

Solvents to Avoid:

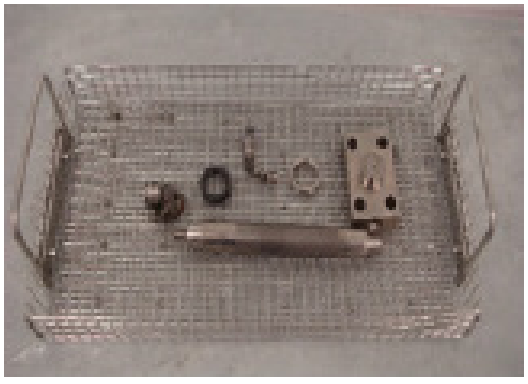
- Chlorinated and fluorinated solvents - I, I, I Trichloroethane, Perchlorethylene, Freon, and other Class 1 or Class 2 ozone-depleting substances should not be used as solvent cleaners.
- Any solvents used should not cause etching, corrosion, or intergranular attack of the metal being cleaned.

Other Solvent Guidelines:

- Any solvent used must be capable of providing parts that meet the cleanliness requirments of equipment drawings, specifications, and customer specifications when applicable.
- Only water-based cleaning agents should be used for the cleaning of non-metallic materials, such as rubbers and plastics.

Cleaning Procedures

1. **Wash or immerse parts with cleaner (pre-clean) -** Remove visible soil, particles and greases
2. **Rinse with water -** Remove cleaning solvent
3. **Intermediate dry** *(optional)* - Dry clean parts if the delay between pre- and final clean may cause oxides
4. **Fully immerse parts in cleaner -** Final clean in NOC (in clean room)
5. **Energize tank and clean the parts -** 5~15 minutes for hardware; no more than 10 minutes for software (O-rings/valve seats)
6. **Collect NOC sample -** Obtain a sample of used NOC
7. **Final rinses: Rinse 1 - ultrasonic water tank, Rinse 2 - Batch tank or flowing water (large parts) -** Remove parts from NOC tank and immediately rinse with water (> 30 sec), remove parts from ultrasonic tank and rinse with water in batch tank (pH value >8)
8. **Collect rinsing water sample for particulate analysis -** Obtain at least 200 mL of the second rinse water as sample
9. **Final dry -** Dry the parts until no moisture is visible
10. **Quality assurance (if particle count fails, replace water & repeat step 7) -** Conduct organic cleanliness (shake and NVR) and particulate (visual and particle count) analysis
11. **Pack and mark -** Package parts in clean room



Analyzing Cleanliness

Inspection prior to use of parts or equipment is key to assuring quality cleanliness. Various types of tests can be performed to assess part cleanliness. Use the following guidelines to analyze cleaned parts:

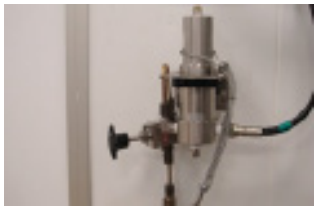
Particulate Analysis

A particulate count should be performed on a sample of the final rinse water or solvent. Particle count for MIL-STD-1330 critical applications are required if requested by customers or procuring activity.

1. **Acquire 250mL effluent water sample obtained from cleaning procedure -** In a clean room, pull sample using sterile plastic bottle, place lid on bottle until ready for sampling
2. **Degas sample -** In clean room, remove sample lid and place sample in testing nest, manually activate vacuum Degas feature for 2.5 minutes, utilizing table timer
3. **Particle count -** Start automated particle counting sequence in clean room
4. **Record result** *(result is count/liter and equivalent to count/01m^2) -* Write down quantity N_c for each particle size that has been recorded on test results print-out
5. **Report result -** Complete certificate with results. Attach print-out to certificate

NVR Analysis Procedure

1. **NOC sample preparation** *(baseline and used NOC - baseline is established before NOC is used to clean parts) -* Collect unused NOC from each container
2. **Membrane filter preparation -** Select 1 Teflon membrane filter at ambient conditions, weigh filter to nearest 0.05~0.1mg and record, place filter in holder and attacher holder to filtration resevoir



3. **Filter used NOC for cleanliness verification -** Homogenize the NOC sample for 3 minutes at 7,500 rpm, using eyedropper or pipette, wet filter with about 1mL of isopropyl alcohol, transfer homogenized NOC to filter reservoir and filter by vaccum or pressurizing reservoir with oil-free air or nitrogen
4. **Wash the filter and reservoir of residual NOC and filter water -** Transfer demineralized water to the filter reservoir and filter by vacuum or pressurizing reservoir with oil-free air or nitrogen, remove filter and place in petri dish
5. **Prepare filters for NVR calculation -** Dry filter with petri dish cover ajar in oven at 131-140°F for 20-30 minutes, remove petri dish with filter from oven, transfer to ambient temperature dish, allow to cool with cover ajar for 2 minutes, weigh filter to nearest 0.1mg; preferably to nearest 0.05mg
6. **Baseline NVR calculation -** Subtract initial weight of filter from final weight after filtering unused NOC for baseline, record weight difference in mg, multiply weight difference by 5 and record as baseline mg/L NVR in NOC, acceptance criteria is 10mg/L
7. **Post-cleaning NVR calculation -** Subtract initial weight of filter from final weight after filtering unused NOC for baseline, record weight difference in mg, multiply weight difference by 5 and record as baseline mg/L NVR in NOC
8. **Post-cleaning above baseline NVR in g/L -** Subtract baseline NVR from the post-cleaning NVR, record the difference as post-cleaning mg/L above baseline NVR in NOC
9. **Post-cleaning above baseline in ppm -** Convert mg/L to ppm by dividing mg/L by 1.075 (average density of NOC in use) and record as ppm above baseline NVR in NOC, acceptance criteria is 5 ppm above baseline
10. **Report result -** Complete cleaning certificate with result



Packaging

Certified oxygen clean components cleaned internally and externally should be packaged wtih appropriate film.

Material Properties	Material: Polyethylene	Material: Nylon	Material: Teflon FEP
Application	Intimate/environmental	Intimate	Intimate
Specification	MIL-B-22191 or equal	Commercial	Commercial
Thickness (approximate)	6 mils	2 mils	2-5 mils
Strength	Low	High	Medium
Sloughing resistance	Low	High	Medium
Moisture permeability resistance	High	Low	High
Gas permeability resistance	High	Low	Low
Oxygen flammability	Medium	Medium	Low
Static charge color coding	Static: natural; Anti-static: pink	Static: natural; Anti-static: orange or yellow-green	Anti-static only; not color coded

Certifications & Training

Certificates of cleaning should be filled in after completion of cleaning processes.

Initial Training: At least one company representative should attend instructional training courses. The representative will provide initial training for workers according to specifications and regulations.

Re-Qualification: Companies should designate one individual as Senior Oxygen Instructor. Remaining personnel should re-qualify every 3 years. Re-qualification may include approved videos and computer-based training media as identified by the organization.

Conclusion

The inherent risks in high-pressure oxygen systems can make usage dangerous, but regularly following best practices for maintenance and cleaning can greatly reduce those risks. Proper guidance on handling oxygen service products is key to avoiding accidents and ensuring personnel and equipment safety. This eBook contains Haskel's recommendations for cleaning procedures, but oxygen cleaning standards are based on usage. For best results and guidance, consult with your engineer on specific protocols for the equipment you use.

About Haskel

With over 70 years of unrivaled expertise in high-pressure, liquid and gas transfer and pressurization technology, Haskel is the solution provider for applications in aviation, defense and aerospace, oil and gas and other critical industries. Haskel meets complex and critical challenges with innovative solutions that ensure safety, reliability and the highest quality. As the clear market leader in high-pressure pumps, Haskel products are made to fit customer needs and market demands. Whether working in oil and gas, automotive and defense or extracting cannabis oil in the emerging medical market, every Haskel product provides the performance that is expected from a global leader.

For more information about our high-pressure products, contact a Haskel representative today.
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