General Industrial and Critical Cleaning Applications

Cleaning and Verification

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# Systems Requiring Chemical Cleaning

- Oxygen (LOX, GOX)
- Ammonia Gas
- Diesel Lines
- Demineralized Water
- Flue Gas Desulfurization (FGD) Absorber Units
- Fuel Oil
- Hydraulic Oil
- Lube Oil
- Methanol
- Natural Gas
- Zero Liquid Discharge Evaporator Vessels

- Cleanliness Requirements and Procedure
- Fabrication and Installation Strategies
- Welding Effects
- Qualified Subcontractor for Component and System Cleaning
- Critical System Preparations
- Basic Cleaning and Passivation Chemistries
- Testing and Verification
**Passivation**  
- Removal of iron and iron compounds  
- Oxidation of surface  
- Chemical treatment designed to enhance the passive oxide film

**Pickling**  
- Removal of scale or metal oxides from the surface; often associated with some metal loss or change in surface finish

**Corrosion**  
- Electrochemical degradation resulting in growth of oxides and loss of metal  
- Initial effects cause surface discoloration and deposits as passive film degrades  
- Penetration of passive layer controlled by alloy

**Chemical Cleaning**  
- Cleaning of product contamination or corrosion products from process surfaces with chemistry
## Specifications for Cleanliness

<table>
<thead>
<tr>
<th>SPECIFICATION</th>
<th>YEAR</th>
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<tbody>
<tr>
<td>ASTM A380 / A967</td>
<td>1999/2005</td>
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<td>ASTM F312 / F331</td>
<td>1997 / 98</td>
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<td>ASTM G93</td>
<td>1996</td>
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<tr>
<td>CGA G – 4.1; 4.4; 34</td>
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<td>IEST STD CC 1246 D</td>
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<tr>
<td>NAS 1638</td>
<td>2001</td>
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<td>SAE ARP 598</td>
<td>2003</td>
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Critical Gas Cleaning Requirements

- The CGA requirements include cleanliness testing of the system after cleaning to meet 47.5 mg/sq. ft. of contamination on the surface and dew point.
- ASTM A967 requirements include alkaline cleaning and passivation of welded and mechanically finished stainless steel.
- Pickling for removal of metal oxides and heat scales are reviewed in ASTM A380 for stainless steel and SCPC – SP8 for carbon steel.
- Pipeline pigging requirements are suggested in CGA for gas lines; diesel and water lines are mechanically cleaned by a pig that moves through the inside of a pipeline for purposes of cleaning, dimensioning or inspecting.
Critical Fluid Cleaning Requirements

• Visual inspection criteria for removal of oxides and organic contamination

• Testing requirements may include cleanliness to meet 1.0 to 20 mg/sq. ft. of contamination on the surface

• Particulate analysis of fluid contained within the system to meet SAE requirements

• Passivation guidelines for stainless steel are reviewed in ASTM A380 and A967
Typical Cleaning Process

- Cleaning Methods:
  - Solvent washing
  - Alkaline cleaning
  - Acid cleaning
  - Mechanical cleaning (pigging process)
  - High velocity oil flushing
  - Gas purging / drying
  - Steam blowing

- Safety Considerations
  - Inspection
  - Fluid, Gas and Surface Testing
  - Component Packaging and Labeling
Tests for Cleanliness

- Visual inspection
- Wipe test
- UV light
- Water break-free surface
- Solvent extraction - NVR
- Particle counting
- Record keeping
Stainless Steel Cleaning and Passivation Benefits

- Chemical cleaning and flushing removes particulate and oxide contamination and organic films
- Passivation increases corrosion protection at weld areas and mechanically damaged surfaces
- Eliminates potential oxidation of contaminants within distribution system
- Clean systems maintain product purity
- Reduction of oxide particulate generation
Stainless Steel Composition

Chromium Enrichment

Nickel Enrichment

Alloy Chemistry

EXTERNAL SURFACE

PASSIVE LAYER

TRANSITION ZONE

ALLOY

BULK PHASE
What Depth Profiles Tell Us About the Oxide Film

Notice the high level of chrome compared to that of iron.

Stainless Steel Surface Analysis

- Oxygen
- Nickel
- Carbon
- Chromium
- Iron
Stainless Steel Welding and Fabrication Effects

- Corrosion resistance of surface effected by grinding, welding and mechanical polishing
- Chrome to iron ratio of surface at weld areas or after grinding will be equal to the base metal (0.3 Cr/Fe) or less
- Oxidation of active surfaces will generate iron oxide particles
- Passivation will restore surface corrosion resistance and a chrome to iron ratio of 1.5+ or greater
Weld Seam Analysis Pre-Passivation

- Welding Affects Surface Composition
- Increased Levels of Chromium Compared to Iron
- Heat Affected Zone (HAZ)
Weld Seam Analysis Post-Passivation

- Passivation Corrects Chrome/Iron Ratio
- Removes Discoloration
- Restores Corrosion Resistance
Acid Pickling for Removal of Oxides

- Acid pickling removes oxides and surface contamination by aggressive chemical attack of the surface.
- Stainless steel pickling is used to remove weld tint and heat effects.
- Carbon steel pickling is used to remove iron oxide corrosion down into the base metal.
- Surface finishes are changed during pickling processes.
Fittings and Connections

- Butt welds – smoothest transition
- Flanges – maintenance, accessibility
- Socket welds – create particle entrapment areas
  - Pre-clean of weld areas
  - Post clean of weld areas
- Threaded connections – particle entrapment
Valve Considerations

- **Connection Types**
  - Flange
  - Threads
  - Socket weld
  - Butt weld

- **Valve Types**
  - Ball – small diameter
  - Butterfly
  - Gate or globe

- Removable spools for cleaning and replacement
- Components must be replaced during cleaning operations, oxygen cleaned, and installed under purge
Pre-Operational Cleaning Requirements

- The system must be free of metal grindings, construction debris and excessive organics (oil and grease)
- The system must contain necessary low point drains and high point vents
- Pneumatic pressure test with all components installed
- Quality welds with no excessive heat effected zones
- Components shall be removed and pre-cleaned
- Spool replacements for all components
Marked Up Flow Paths
Astro Pak Specialized Equipment

- Dedicated mobile flushing cart
- Variable speed drive pump controller
- Filtration unit
- Reverse flow manifold
- Pressure / Temperature Gauges
What is Chelation?

- Chelants (citric acid, EDTA) dissolve and ionically bond to form metal complexes
- Removes iron oxides, metal inclusions, sulfides and aluminum
- Prevents precipitation of iron after processing
- Creates best corrosion resistant passive surface on stainless steel
Benefits of a Citric/Chelant Process

- Environmentally friendly, non-hazardous chemistry
- Easier to dispose
- Low affinity for chromium
- Maximum iron removal
- Minimized personnel exposure
Trends in Cleaning Chemistry

- Maximize Oxide Removal
- Reduce Chemical Aggressiveness
- Make Safety a Bigger Consideration
- Consider Environmental Impact
Establishing an Effective Passivation Procedure

- Use an accepted and scientifically tested procedure
- Prove the procedure on weld coupons from job site samples
- Perform scale removal testing to optimize procedures for descaling
- Design special treatments for specific conditions and alloys
Planning a Successful Cleaning Project

- Identify the scope of work
  - What gets cleaned and what does not
- Be aware of chemical options for cleaning
  - Inorganic and organic acids
- Consider chemical application methods
  - Circulation, spraying, intermittent one way flow, immersion, swabbing
- Define the cleaning and passivation procedure
  - Chemical: time, temperature and concentration
  - Chemical diluent and rinse water quality
- Verify the effectiveness of the cleaning procedure
Planning a Successful Cleaning Project

• Schedule the cleaning project
• Mark up P&I drawings to indicate flow paths
• Confirm that required utilities will be available
  – DI water, plant steam, electricity, plant air, etc.
• Document the entire process
  – Use appropriate forms to record pertinent data
• Consider the disposition of the system being cleaned
• Make provisions for proper disposal of waste solutions
Carbon Steel Cleaning

- Alkaline cleaning and flushing removes particulate contamination and organic films
- Citric acid cleaning removes iron oxide accumulations
- Nitrite passivation provides temporary corrosion protection on carbon steel surfaces
- Nitrogen drying
Carbon Steel Cleaning Procedure

• Initial water flush and leak test
• Alkaline cleaning with detergents remove surface debris and organic films
• Citric acid cleaning solution for iron removal
• Nitrite passivation
• Final water rinse
• Rinse with alcohol or high purity solvent
• Dry with clean, dry nitrogen and test for dew point
• Purge system for installation of components and final pneumatic testing
PART 1: CLEANING

- Solvent specifications require use of non-flammable organic solvents
- n-propyl Bromide, AK-225, & Vertrel MCA are Freon replacement solvents
- “Ozone Depleting” or solvents such as 1,1,1 Trichloroethane are regulated solvents
PART 2: DRYING

- Alkaline cleaners require final DI water rinse
- Complex piping systems are difficult to dry with entrapments
- flushing with solvent will blend with residual water and lower vapor pressure (IPA or Acetone)
- Nitrogen gas purge
- Allows attainment of -30°F dew point or better
Lube Oil Flushing

• Flow rates to meet specification
  – Typically 5 ft./sec. for 6”+
  – 10 ft./sec. for 1” thru 4”

• High pressure equipment necessary for small bore flushing

• Laser particle counter helpful in process verification

• Flushing oil to be capable of water entrainment unless drying is verified

• SAE AS-4059 or NAS 1638 ranges for cleanliness determination by particle counts
Post Cleaning Requirements

- Pre-cleaned and certified components
- Removal of spools & replacement of components within clean area & use of gas purge
- Final gas testing of system
Disposal of Waste Solutions

• Discharge directly to treatment system
• Neutralize on site
  – Discharge to chemical drain
  – Discharge to sanitary drain if criteria of site waste stream is met
• Off site disposal
  – Manifest hazardous waste
  – Bill of lading non-hazardous waste
Does Your Contractor…

☑ Submit procedures and chemistry?
☑ Review drawings and circuit designs?
☑ Discuss connections to equipment?
☑ Provide documentation package with?
  – Iron solubility testing?
  – Process certification?
  – Chemical certificate of analyses?
  – Instrument calibration records?
Summary

• Critical clean gas distribution piping systems require a clean and organic free, corrosion resistant surface.

• Fabrication operations reduce cleanliness and corrosion resistance which is why cleaning and passivation is required.

• Compliance with CGA / ASTM / SAE specifications.

• Proper testing and certification of cleanliness is required.

• Collaboration between engineering design, mechanical installation and precision cleaning contractor is needed.

• Systematic preparation, clean fabrication and proper cleaning methods result in improved component performance, ease of system maintenance and overall safety of operations.
Company Profile

• Established in 1959
• Headquarters: Costa Mesa, CA
• Industry Leader in precision, high purity and chemical cleaning services
• Uniquely positioned for large, complex projects
• Named “Small Business of the Year” by the Dept. of Energy
QUIZ – Part 1

1. Quality passivation processes will improve the chromium to iron ratio to:
   a) 0.3
   b) 1.0
   c) 1.5
   d) 5.0

2. Pickling is a process that:
   a) Passivates the surface
   b) Removes oxides and scales with metal loss from the surface
   c) Does not affect surface finish
   d) Smoothes the surface to improve corrosion resistance

3. Chelant Passivation provides:
   a) A more corrosion resistant surface
   b) Non-hazardous waste disposal considerations
   c) Higher chromium to iron ratio
   d) All of the above
4. **Lube Oil flushing processes involve:**
   
a) Particle removal from lube oil distribution systems
b) Flushing oil that dissolves water residue instead of dispersing it
c) Removal of rust and scales from welding
d) Large bore piping that requires high pressure to flush at 3 feet per second

5. **Critical gas systems:**
   
a) Do not require rust free corrosion resistant surfaces
b) Require a visibly clean, particle free and organic free surface
c) Are cleaned by gas blow downs
d) Pigging is used to test CGA cleanliness of piping system
1. C
2. B
3. D
4. A
5. B
Questions?

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