Cleaning Strategies for UHV

Ron Reid
Group Leader, Vacuum Science Group
ASTeC
CCLRC Daresbury Laboratory
Warrington WA4 4AD, UK

Why Do We Need To Clean For Vacuum?

- We may not always need to!
  - It depends on what we need vacuum for
    - Vacuum regime required (Base pressure)
    - Cleanliness
  - So we need to make a proper assessment of the real requirements of the application
  - But for UHV and XHV it is highly likely that some form of cleaning will be needed

Some Reasons for Cleaning

- Irrespective of the application – a manufacturer desires an attractive appearance!
- Characteristics of a surface (surface properties) may be altered by ‘contamination’ at the surface.
- Process may be poisoned by ‘contaminants’
- Quality of an in-vacuum process severely affected by presence of ‘contaminant’ gas phase molecules
- ‘Contaminant’ - a contaminant in one application may be an essential constituent of another!

Why Clean Accelerator Vacuum Systems?

- To ensure maximum transmission of particles and electromagnetic radiation
  - reduce beam-gas scattering
  - radiation absorption
- To reduce scattered radiation for health & safety (bremsstralüng)
- To maintain clean in-vacuum surfaces
  - preventing target poisoning
  - maintaining efficient optical properties for em radiation transmission
- To provide a controlled atmosphere

Vacuum System Design Issues

- The Vacuum Engineer should consider the following at the design stage:
  - How all parts can be cleaned (initially and in service)
    - Component level clean
    - Full assembly clean
    - Sub-assembly clean
- Cleaning Plant
  - Size
  - Robustness
  - Handling/Risks

Trapped Areas
Solvent Trapping

Vacuum System Design Issues

- Material choice
  - Porosity
  - Effect of cleaning on tolerances
  - Multiple materials
    - Varying effects of cleaning process
    - Risk of electro-chemical action (galvanic cell)
- Assessment of cleaning effectiveness

Requirements for UHV/XHV

- Minimise desorption
  - Remove ‘contaminants’ (i.e. components with high outgassing/vapour pressure)
  - Deplete reservoirs
    - Bulk gases
    - Surface overlayers (e.g. adventitious graphite)
  - Provide barriers
    - Bulk diffusion

How do we know if a surface is clean?

- Phenomenologically
  - Measure outgassing (thermal desorption)
  - Measure stimulated desorption (according to requirements of system)
  - In each case total and partial pressure measurements useful
- Characterise surfaces
  - Surface analysis

A Distinction

- Differentiate between
  - Cleaning
    - Removal of unwanted components
  - Passivation
    - Formation of barriers
    - Low sticking probabilities

Some examples of cleaning processes

- Solution
  - Water based
  - Solvent based
    - Alcohols
    - Chlorinated hydrocarbons
    - Freons
- Detergents
- Etchants
  - Acids
  - Alkalis
- Vacuum Baking/Firing

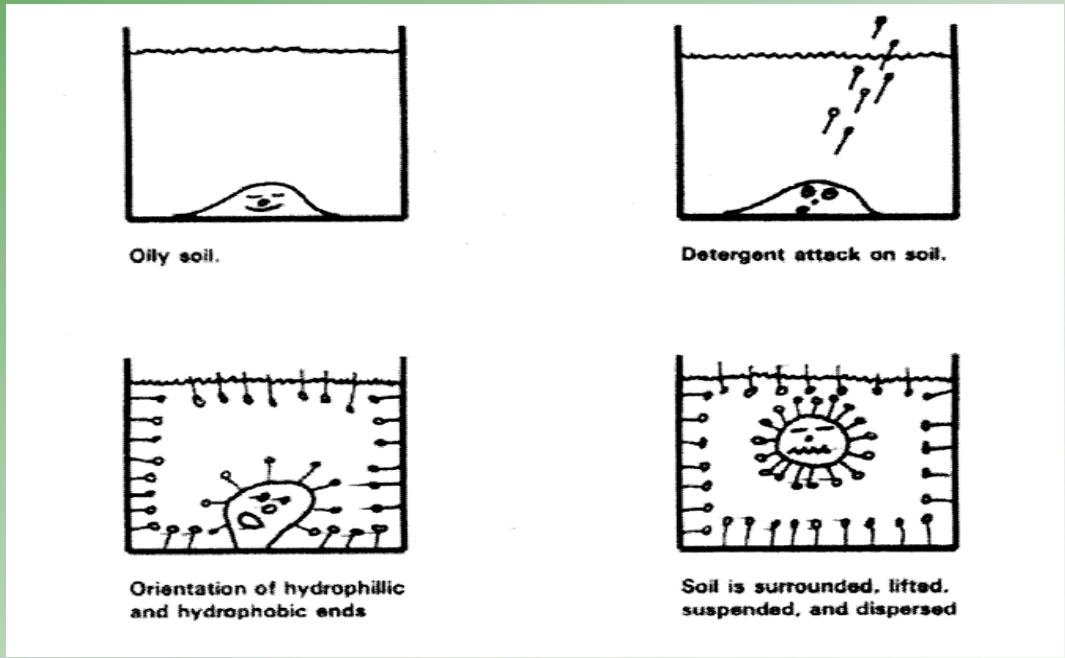
Some examples of passivation

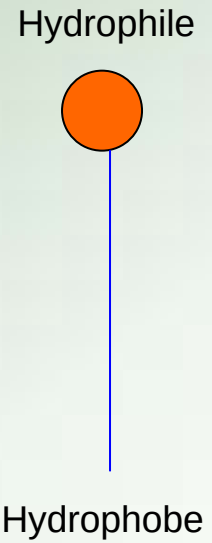
- Air Baking
- Electropolishing
- Glow Discharge

- But note that **all** of these have some cleaning effect!

Science of Cleaning

- **Solvent** - A **solvent** is a substance that dissolves another substance or substances to form a *solution* (a homogeneous *mixture*). The solvent is the component in the solution that is present in the largest amount or is the one that determines the *state of matter* (i.e. solid, liquid, gas) of the solution.
- **Surfactants** - surface active agent





Science of Cleaning

- **Penetrating and Wetting agents**

  Surfactants which change the chemical composition of the hydrophobic and hydrophilic ends of the molecule, this opens up the possibility of

  Detergency

  Foaming

  Emulsifying

  Solubilising

  Dispersing

- **Chelators -** remove the hardness in water
- **Saponifiers -** convert animals fats into natural soaps

Typical Cleaning Agents

Agent	Examples	Advantages	Disadvantages	Disposal
Water		Cheap, readily available	Need de-min for cleanliness. Not a strong solvent	To foul drain
Alcohols	Ethanol, methanol, iso-propanol	Relatively cheap and readily available. Quite good solvents	Need control – affect workers; some poisonous; some flammable; stringent safety precautions.	Evaporate or controlled disposal.
Organic Solvents	Acetone, ether, benzene	Good solvents, evaporate easily with low residue.	Either highly flammable or carcinogenic	Usually evaporate
CFC's	Freon™ (CFC-113)	Excellent solvents; evaporate easily with low residue	Banned	Strictly controlled, must not be allowed to evaporate
Chlorinated hydrocarbons	Trichloroethylene (Trike™)	Excellent solvents. Non-toxic. Low boiling point. Low residue	Trike may be banned. Toxic, require stringent safety precautions.	Strictly controlled
Detergents		Aqueous solutions, non toxic. Cheap and readily available. Moderate solvents.	Require careful washing and drying of components. Can leave residues.	To foul drain and dilution
Alkaline degreasers	Almeco™, sodium hydroxide	Aqueous solutions, non- toxic. Moderate solvents	Can leave residues and may throw particulate precipitates	Requires neutralisation, then dilution to foul drain.

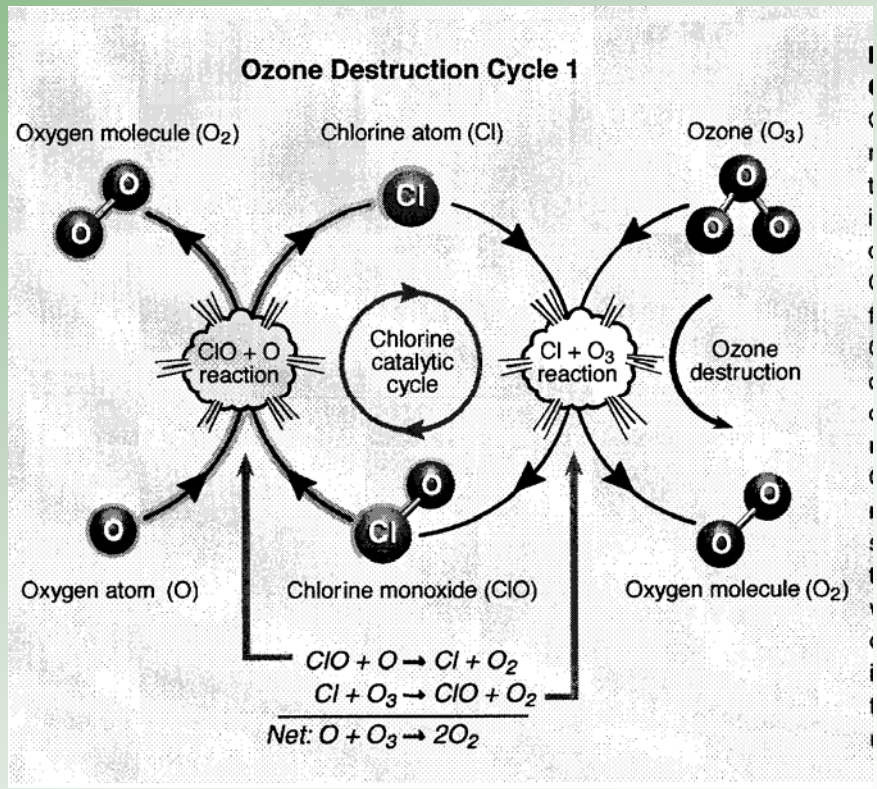
Some actual cleaning processes

SRS	ANKA	BESSY II
Hot water jet with detergent	Coarse cleaning with Chesterton (KPC820)	Wipe off surface dirt
Surface stripping with alumina beads	Rinse in hot de-min water	Ultrasonic with trichloroethane
Ultrasonic wash in hot Triklone	Ultrasonic wash in hot P3-Almeco 18	Treatment with hot perchloroethylene (120°C)
Vapour Wash in hot Triklone	Rinse in de-min water	Ultrasonic cleaning in hot P3-Almeco 18 for 10 minutes.
Rinse with de-min water	Dry in warm dust free air, bag and seal.	Rinse for 15 minutes with tap water.
Immerse in hot alkaline bath of P3-Almeco 36 at 60°C		Wash in hot de-min water for 90 minutes.
Rinse in de-min water		Open air drying and cooling of components.
Dry in warm, dust free air, bag and seal.		

Current legislative situation

- **Vienna Convention - 1985**
- **Montreal Protocol - 1987**
  - Amendments - most recent 2000
  - Protection of the Ozone Layer
  - CFC's
  - HCFC's
  - Carbon Tetrachloride
  - Methyl Chloroform
  - Other halogenated hydrocarbons
- **Why Change?**
  - **Reclassification of 1,1,2-Trichloroethylene (Trike^{TM})**

    Improved Health and Safety regulations



Future possibilities

- Other solvents
  - Further n-propyl bromides
  - Non flammable ethers
  - …….
- Aqueous systems
  - e.g. Micro 90

What strategy should be adopted?

- The least that is proved to be effective for the task in hand
- But understand what is required and the limitations of each process
- Pay enormous attention to detail
- Pay enormous attention to health and safety!

Acknowledgments

- Joe Herbert
- Keith Middleman