* **Sample dehydration**
* **Analysis environment**

CONTAINER CLEANLINESS

The cleanliness level of sample containers, process fluids, and the surfaces of analysis equipment are all external influences affecting the validity of particulate contaminant analysis. The manner in which a crucial item is cleaned is not nearly as important as having complete confidence in its cleanliness.

Using new, or "surgically clean" bottles as fluid sample containers is totally inadequate. Bottles free from live microorganisms may contain a high level of organic and inorganic particulate matter. Individual particles below approximately 40 micrometres cannot be seen with the naked eye. However, the fact that particles or soil are not visible is no assurance of a container's cleanliness level.

One fact worth remembering is that effective cleaning of any component depends not only on separating and dislodging particulate matter from its surfaces, but also on the cleanliness level of the rinsing fluid. Experimental studies have shown that, under ordinary conditions, an ultrasonic bath with a power level of at least 10 watts per sq. in. of bath area is necessary to detach particulate matter from most surfaces. Ultrasonic wave transmission increases when detergents are added to the fluid. Detergents are also helpful in removing oil films and soil from the surfaces to be cleaned.

As a guide for those wanting to establish a **cleaning procedure** for sample containers, the procedure used by the FPRC/OSU may be of help --

1. Dump contents of sample container, rinse container with ether, and arrange containers into batches of 20.
2. Fill ultra-sonic unit with hot water and 50 mL of ZZ Chemical Cleaner.
3. Insert bottles and let soapy water run into them.
4. Cover the ultrasonic with a sound suppressant top and operate ultrasonic for 5 min.
5. Drain water from bottles, and rinse soap from the tank and bottles.
6. Rinse bottles once for 5 min. by filling the ultrasonic and bottles with clean hot water and 10 mL of reagent grade acetic acid to neutralize the alkaline effects of the cleaner.
7. After the ultrasonic rinse, flush each bottle with "soft" tap water; then, drain and turn upside down in drying rack.
8. Rinse thoroughly with alcohol and then with ether.
9. After the ether evaporates (fumes are no longer exiting from the mouth of the bottle), spray a plastic square with ether and let it dry.
10. Cover the bottles with the sprayed side of the plastic; put a rubber band around the bottle neck and cap.
11. Continue until 20 bottles are completed. Keep the bottles upside down at all times until the opening is covered with plastic.

Evaluating Container Cleanliness

The **cleanliness level of a sample container** can be evaluated by using the following procedure:

1. Fill the container to 50 (plus/minus 5) percent with super clean fluid having a cleanliness level less than one particle per mL greater than 5 micrometres (in 10 mL of fluid there should not be any particles greater than 10 micrometres).
2. Replace the film covering and cap. Shake the container vigorously.
3. Using an automatic particle counter calibrated per ISO Standard 4402, determine the number of particles per millilitre of fluid greater than 10 micrometres.
4. Multiply the particle count by the ratio -- (fluid volume added to the sample container volume divided by the total sample container volume).

The number obtained in Step 4 is the container cleanliness level in particles greater than 10 micrometres per mL of container volume.

ISO Quality Assurance

ISO Standard 3722, for qualifying and controlling cleaning methods for fluid sample containers, ignores the technique by which the containers are cleaned. The qualifying procea fairly simple operation to a complex process. Packaging techniques have been developed which, when coupled with a knowledge of the elements of clean packaging, can produce a package as clean as material technology permits. Since the objective of clean packaging is to maintain a specified cleanliness level for the enclosed item, some inspection or testing techniques should be applied to verify that this cleanliness level is, in fact, maintained.

FLUSHING -- SYSTEM CLEANING

Flushing is a fluid circulation process designed to remove contamination from the wetted surfaces or "innards" of a fluid system. Such contamination results during system manufacture, service, and overhaul. It is not unusual for a fluid system to be seriously contaminated because of assembling elements with dirty or oxidized (corroded) surfaces, disintegrated components (metal-debris-generating failure), heavily encrusted corrosion, brokendown fluids, injected and ingested chemical contaminants (air, water, solvent, etc.), and dissolved incompatible elastomers (seals, sealants, coatings, hose liners, etc.). If the system is to avoid rapid component wear, malfunction, and breakdown, its concentration of contaminants must be reduced and maintained at a level needed to achieve the desired system design service life.

Even though all components and conductors comprising a system are meticulously cleaned prior to assembly, exposing the internal surfaces to the environment during assembly or overhaul and generating debris simply by joining conductors to components can create an intolerably dirty system. Hence, flushing is a necessary procedure and should be considered part of the system-commissioning operation.

The manufacturer is responsible for establishing the flushing operation, the required cleanliness level and the proper assessment procedure. The manufacturer, or the OEM, selects the components, establishes their compatibility, knows their contaminant tolerance levels, and possesses the insight to specify the degree of system cleanliness necessary to achieve service life and reliability target values. Furthermore, the manufacturer (the system designer in this case) is in a unique position to establish the flushing plan -- divide the system for optimal flushing, design the component substitution blocks (flushing blocks or jumpers to bypass unnecessary or delicate flow-sensitive components), and locate air bleeders, drain and sampling ports, etc. Due to the complexity, size differences, and inherent component peculiarities of fluid systems, it is unfair to expect anyone but the manufacturer and system designer to formulate such a plan. The flushing methodology should be considered and incorporated from the beginning of the design and not be devised in desperation by manufacturing, maintenance, or overhaul personnel.

Condition of Internal Surfaces

Clean fluid circulating in the system cannot clean rust and scale from the piping, deburr machined elements, or remove flux or weld slag. All components (including conductors) that comprise the fluid system should be clean, inhibited with preservative fluid, and have all openings sealed. Temporary sealing devices should only be removed prior to assembly.

Particular attention should be given to fluid conductors -- hoses, fittings, tubing, and piping. Dirty conductors should either be rejected and replaced or cleaned before assembly. Open ends should be protected by moldable wrappings or caps, not plugs.

Components and conductors protected by a proper filter (200 mesh screen or better) at the time a metal-debris-generating failure occurs can be considered "clean." Thus, a flushing plan should include instructions on the type of flush and how to flush at the time of roll-off as well as after specific failures have occurred. Components containing metal-wear debris (greater than 74 micrometres in size) on their wetted surfaces should be disassembled and cleaned under controlled conditions or by washing with directed jets of clean fluid at high velocity.

Levels of Flushing

Three levels of flushing or system cleaning are practiced:

* **Recirculation Cleaning**
* **Solvent Cleaning**
* **Chemical Cleaning**

Recirculation cleaning is used to decontaminate a fluid system with respect to particulate matter, air, and water. Such contaminants result from normal injection, generation, and ingestion activities as well as component wear-out failure and mishaps. In this type of flushing, the fluid normally used in the system serves as a vehicle to --

* Mechanically dislodge, lift, and entrain particulate debris
* Suspend and transport the particles
* Absorb air and water from the system
* Release the contaminant to a filter for ultimate removal from the system

In recirculation cleaning, how effectively the air and water is removed depends on the hygroscopic and solubility characteristics of the fluid and the means by which the fluid is stripped of the contaminants. The particle removal performance of a flushing method depends on the lift forces, drag forces, and depth of the laminar sub-layer in the stagnant film next to the conduit wall.

A particle completely submerged in the laminar sub-layer is impossible to flush from the system. Hence, to remove a given size particle at the wall, the Reynolds number must be increased until the thickness of the laminar sub-layer is less than half the diameter of the particle -- see Figs. 3-20, 3-21, and 3-22. Particles smaller than twice the sublayer thickness cannot be removed by flushing.

Solvent cleaning dissolves, chelates, or emulsifies soluble deposits that cannot be flushed from a system by recirculation cleaning. Organic deposits (such as rust inhibitors, preservatives, cutting oil, pipe dope, and varnish) are generally removed by organic solvents emulsified with inorganic solvents.

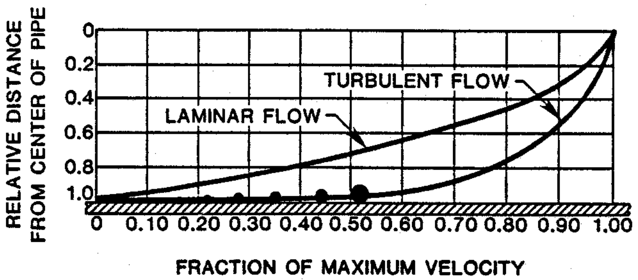

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Fig. 3-20. Velocity Distribution of Laminar and Turbulent Flow Fields.

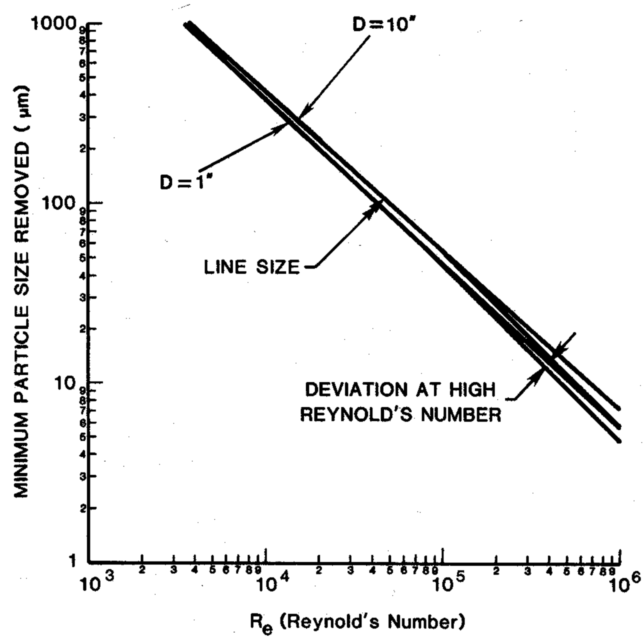

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Fig. 3-21. Minimum Particle Size Versus Reynold's Number.

These deposits, if not removed, will slough due to thermal expansion and system operation and continue to contaminate the system fluid for a long period of time. They cannot be removed by recirculation cleaning because the solvency power of the system fluid is not great enough to remove them.

Chemical cleaning uses chemicals that can dissolve or chelate inorganic contaminants. The entire family of iron oxides and other oxidation products often exist near field welds in the form of slag and fluxing compounds. When these contaminants are present and must be removed, chemical cleaning offers the only choice.

Preparing a System for Flushing

In designing a flushing plan, the system should be carefully subdivided into compatible flushing sections based on the following criteria:

* Combining lines that flow in the same direction and those where the flow normally reverses direction
* Combining lines of similar size where a specified Reynolds number can be maintained without exceeding flow and pressure drop limits of the components