



Workshop on Medical Device Cleanliness: How Clean is Enough?

Sponsored by ASTM Committee F04 on Medical and Surgical Materials and Devices

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Workshop Co-Chairs:

Reto Luginbuehl
Robert Mathys Foundation
Bettlach, Switzerland

Stephen Spiegelberg
Cambridge Polymer Group
Boston, MA

Terry Woods
FDA
Silver Spring, MD

TUESDAY, NOVEMBER 16, 2010

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Program
TUESDAY, NOVEMBER 16, 2010

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Reto Luginbuehl, Robert Mathys Foundation, Bettlach, Switzerland
Stephen Spiegelberg, Cambridge Polymer Group, Boston, MA
Terry Woods, FDA, Silver Spring, MD

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Pamela Scott, Daniel McGunagle, FDA, Silver Spring, MD

The Legal Implications of Medical Device Cleanliness Standards

Steve Bennett, John Schlafer, Baker & Daniels, LLP, Fort Wayne, IN

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Jahan Azizi, Linda Lavey, CBET, University of Michigan, Dearborn, MI, USA

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Bradley Catalone, Thomas Gilmore, David Barlow, Olympus America, Center Valley, PA, USA

Effects of Non-Aqueous Vapor Degreasing Solvent Cleaning on Ultra-High Molecular Weight Polyethylene (UHMWPE)

Ray Gsell, Zimmer, Warsaw, IN, USA

Breaking the Myth that Caustic Surgical Instrument Cleaners are Necessary for Safe and Effective Decontamination of Medical Devices

Marcia Frieze, Case Medical, South Hackensack, NJ, USA



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SESSION 3: CLEANING AND TESTING, PART 2

Cleaning and Testing for Debris in Reusable Medical Devices

Shani Haugen, Vicki Hitchins, FDA, Silver Springs, MD, USA

Evaluation of the Cleaning Efficiency of a Aqueous Based Detergent System for Cleaning Metallic Medical Devices

B. Dhanapal¹, N. Weiler¹ and J. Rufner², ¹Zimmer GmbH, Switzerland, ²Zimmer Inc, Warsaw, IN, USA

Two-phase Flow Cleaning of Endoscope Channels

Mohamed E. Labib¹, Stanislav Dukhin¹, Joseph Murawski¹, Yacoob Tabani¹, Richard Lai¹ and Michelle Alfa²,
¹Novaflux Technologies, Princeton, NJ, USA, ²St. Boniface General Hospital, Winnipeg, Canada

Assessment of Organic Residues on Medical Devices

B. Dhanapal¹, D. Zurbrügg², J. Rufner³, R. Gsell⁴, ¹Zimmer GmbH, Switzerland, ²Niutec AG, Switzerland, ³Zimmer Inc, Warsaw, IN, USA,

SESSION 4: ESTABLISHING CLEANING LIMITS

Establishing and Justifying Limit Values for Residual Analysis

Kierstan Andrascik, QVET Consulting, Layton, UT, USA

Residual Soil on Reusable Medical Devices: How to Determine Limits?

Steve Goldstein, Steve Goldstein Consultants, Albuquerque, NM, USA



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SESSION 1: FDA AND LEGAL IMPLICATIONS

Reprocessing of Reusable Medical Devices: an FDA Perspective

Pamela Scott, Daniel McGunagle, FDA, Silver Spring, MD

Ineffective reprocessing of reusable medical devices continues to present a public health risk and reports to FDA from numerous facilities highlight problems with contamination and debris retention. The FDA believes that the incidents can be prevented through approaches including (but not limited to): (1) improved labeling and cleaning practices, (2) rigorous validation of the reprocessing instructions, (3) design features that facilitate cleaning and (4) user facilities implementing strong quality assurance programs. The recently published “Safety Communication from FDA, CDC and the VA: Preventing Cross-Contamination in Endoscope Processing” is one example of specific actions to reduce risk. At this workshop, FDA staff will discuss best practices for the reprocessing of all reusable medical devices.

The FDA actively works with manufacturers, facilities and health care professionals to improve the reusable medical device landscape and to strengthen standardized practices for reprocessing. Drawing on clinical standards and FDA guidance, FDA staff will touch on key program areas where there are opportunities to improve the effectiveness of reprocessing of reusable medical devices.

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The Legal Implications of Medical Device Cleanliness Standards

Steve Bennett, John Schlafer, Baker & Daniels, LLP, Fort Wayne, IN

The question "How clean is clean enough?" has been approached and answered in different ways in the legal world. Some focus on a manufacturer's validated cleaning process; others on one specific result, the absence of residue. The discussion and debate over cleanliness standards and contamination have been and will continue to be played out against the backdrop of product liability litigation, product recalls, and patient safety concerns. Therefore, the development of cleanliness standards by the ASTM will have legal implications for stakeholders in the medical device field.

An industry standard for cleanliness that defines acceptable residue limits, as well as appropriate testing methods for certain residues, will impact the defect analysis in product liability litigation. An ASTM cleanliness standard could become the guidepost for determining whether a specific explanted medical device contains a manufacturing defect, i.e., a deviation from the intended design specification. Accordingly, consideration should be given to the utility of such a standard in the context of explant analysis for contaminants.

A cleanliness standard also could be used as a legal framework for determining the adequacy of a manufacturer's cleaning and quality assurance processes. Inconsistencies between a manufacturer's cleaning process and an ASTM cleanliness standard might expose a manufacturer to the claim that a medical device is defective. On the other hand, an ASTM standard could be used by a manufacturer to defend its validated cleaning process as "state of the art" or in conformance with industry standards.

Consideration also should be given to the interplay between an ASTM cleanliness standard and the requirements of regulatory bodies. For example, the FDA's Good Manufacturing Practices regulations require manufacturers to have procedures "for the use and removal of such manufacturing material to ensure that it is removed or limited to an amount that does not adversely affect the device's quality." 21 C.F.R. § 820.70(h). The regulations do not define specific residues, residue limit values, or methods for testing. A medical device industry standard that provides those definitions may have an impact on cleanliness regulations or the legal interpretation of the regulations.

This presentation will touch on all of the above legal ramifications of defining or not defining acceptable residue limits. Case examples will be presented, and litigation, regulatory, and risk management considerations will be addressed.

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SESSION 2: CLEANING AND TESTING, PART 1

Exploring Methods of Optimizing Surgical Instrument Reprocessing Operations

Jahan Azizi, Linda Lavey, CBET, University of Michigan, Dearborn, MI

The elimination of bioburden from reusable surgical instruments represents an ongoing challenge for the manufacturers of such instruments, the hospitals using them, and the patients relying on them for their health and safety. Recognizing this challenge, a team of risk management personnel and instrument room technicians at the University of Michigan Hospitals and Health Centers have undertaken a project focusing on directed testing of the manufacturer's recommended cleaning methods for surgical instruments.

The objective of this testing is to determine the efficacy of automated instrument reprocessing methods with the goal of finding the optimum means of sterilizing valuable surgical tools. Faced with an array of instruments available for testing, investigators settled on suction tips, useful due to their application in virtually every kind of surgery, their exposure to high levels of bioburden, and their known difficulty to clean. This study focuses on a variety of suction tips used in orthopedic, neurosurgery, and otolaryngology surgical procedures.

Methods involve a dedicated workstation designed for this project and set up with a Midbrooks reprocessing machine; a digital video outfit for taking intra-lumen snapshots using flexible scope cameras ranging in size from 1.9 mm to 2.7 mm; and supplies for determining the presence of protein, ATP (adenosine triphosphate), carbohydrate, and hemoglobin as markers for bioburden still present. In addition, enzyme solution and hand tools for manual cleaning were available for continued testing as needed. Testing so far has included three phases:

Phase 1: Visual check: Suction tips are tested for protein before and after cleaning. Still photographs are taken throughout, showing bioburden present.

Phase 2: ATP Check: A sample of suction tips is tested for ATP and hemoglobin.

Phase 3: Comparison Testing Using ATP and Channel Check (testing for protein, hemoglobin, and carbohydrate): Instruments undergo cleaning using the manufacturer's recommended processes, requiring as many as three wash cycles. All are tested using ATP and hemoglobin test kits after each cycle.



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Initial testing found bioburden remaining on 100% of the instruments. Additional cleanings were required to reach a predetermined cleanliness goal. While still focusing on suction tips, investigators also tested additional instruments as available, including samples of endoscopes and robotic control devices.

Testing is ongoing, with the ultimate goal of finding a process that will reliably produce a verifiably clean instrument after a set process is performed, time and time again, to meet the needs of a busy teaching hospital while providing patients with the best possible care. Results so far have been eye-opening, both with regard to the bioburden left behind and in the obvious limitations of the manufacturer's recommended cleaning processes. Ample photographs and numerical data rendered in charts and other graphical means offer an opportunity to share the scope of this project.

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Validation Strategy for an Automated Endoscope Reprocessor

Bradley Catalone, Thomas Gilmore, David Barlow, Olympus America, Center Valley, PA

Flexible endoscopes are complex devices with design features that present a challenge to effective reprocessing: including multiple, long, thin internal lumens that may bifurcate and/or extend the length of the endoscope; and a variety of models, each with a unique design and particular steps for reprocessing. One mechanism by which to address the challenges presented for effective endoscope reprocessing is to automate the parts of the process that are performed manually and which account for much of the observed variability in clinical practice. Several studies have identified manual cleaning as the most labor-intensive and variable part of endoscope reprocessing. This presentation describes a system level approach to validating an automated endoscope reprocessor that takes over many of the manual steps in the process.

There are clear benefits to automation of a variable process, including consistency and repeatability. However, there is also a risk in which the user is no longer intimately connected to the device and is unable to detect abnormal conditions that may present a challenge to the effectiveness of the reprocessing procedure. As a result, the validation strategy for an automated endoscope reprocessor must be both rigorous and robust to account for any potential variability in clinical practice.

Our validation strategy was developed at the system level to account for variables in AER performance, degradation and organic loading of the chemistry, selection of the most challenging device(s) to reprocess, and failure to follow manufacturer's instructions prior to automated reprocessing. The AER was modified to simulate conditions just prior to preventative maintenance and the high-level disinfectant was stressed with an organic load, diluted to its minimum recommended concentrations and used at or beyond its specified use life. In addition, a comprehensive evaluation of all devices specified for reprocessing in the AER was performed to identify those devices that either individually or in combination with another device represented the worst-case challenge to the reprocessing procedure. To complete the strategy, the validation accounted for user failure to perform the indicated manual process prior to automated reprocessing, thereby building into the process an inherent safety margin for effective reprocessing.

An appropriate validation must include a relevant and validated test soil. The previously validated soil used in this study contained organic components at levels similar to worst-case patient soil levels for GI and pulmonary endoscopic procedures and two primary indicators (protein and hemoglobin) of cleaning efficacy were selected.



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We targeted previously published endpoints for both residual protein ($< 6.4 \mu\text{g}/\text{cm}^2$) and hemoglobin ($1.8 \mu\text{g}/\text{cm}^2$). These endpoints were based upon residual levels consistently achieved through optimal manual cleaning, which is the currently accepted standard for endoscope cleaning.

A total of thirty-six samples from nine endoscopes tested following AER reprocessing under worst-case simulated use conditions met the pre-established acceptance criteria for protein ($<6.4 \mu\text{g}/\text{cm}^2$) and hemoglobin ($<1.8 \mu\text{g}/\text{cm}^2$) residuals. Although the validation testing indicated that AER reprocessing alone provides effective cleaning of flexible endoscopes such that the manual cleaning process can be eliminated, users were instructed to perform external surface cleaning and channel brushing prior to AER reprocessing. The additional requirement for the manual cleaning steps provides enhanced cleaning, verifying that the instrument/suction channel of the endoscope is not obstructed, and maintains the connection between the reprocessing technician and the device.

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Effects of Non-Aqueous Vapor Degreasing Solvent Cleaning on Ultra-High Molecular Weight Polyethylene (UHMWPE)

Ray Gsell, M. Guo, H. Brinkerhuff Zimmer, Warsaw, IN

Introduction: Non-aqueous vapor degreaser cleaning (NAVDC) methods have been used for many years. Their main applications have been for cleaning metal products. These processes had become less popular because of environmental concerns and regulations on ozone depleting materials; a classification which included many of the solvents commonly used. With recent advances in equipment technology that essentially eliminated solvent loss to the environment and the development of suitable non-ozone depleting solvents, there has been a renewed interest in this technology. The use of NAVDC for cleaning metallic devices is relatively straight forward and well understood. Although its application to polymeric devices requires greater knowledge and control of the solvent-polymer interactions, many polymeric systems (e.g. circuit boards) are successfully cleaned with this technology. UHMWPE is the major polymeric material used by the orthopaedic industry in manufacturing artificial joints. If NAVDC processes are to be used on these materials it is important to understand the effects residual solvent has on the mechanical properties (short and long term) of the UHMWPE and product packages and the biocompatibility of NAVDC materials. The subject of this paper is to discuss some of the effects of NAVDC on UHMWPE.

Materials and Methods: Two commercially available hydrofluorocarbon solvents were evaluated: HFE-72DA (3M Company) and Heavy Duty Degreasing Solvent (Micro Care Corp.). Both are mixtures containing trans-dichloroethene and fluorinated hydrocarbons. The UHMWPE used was non-irradiated compression molded GUR-1050 slab (Ticona) machined into test bars approximately 6 x 12 x 40 mm. The UHMWPE test bars were processed in the boiling solvents and their vapors with and without sonication for 2 – 5 minutes (see Table 1). The absorption/desorption depths and rates of a solvent on a processed bar was monitored using FTIR line scan mapping techniques (Nicolet Magna 500 FTIR coupled to a NicPlan FTIR Microscope). Desorption of absorbed solvent was evaluated at ambient conditions, elevated temperature and ambient pressure (oven) and elevated temperature and sub-ambient pressure (vacuum oven). The presence or absence of absorbed solvent in the UHMWPE was easily detected by FTIR because each solvent has several unique absorption bands that are non-interfering with the UHMWPE absorption bands (e.g. Figure 1).

Results:

Figure 1
FTIR Spectra of HDS vs UHMWPE

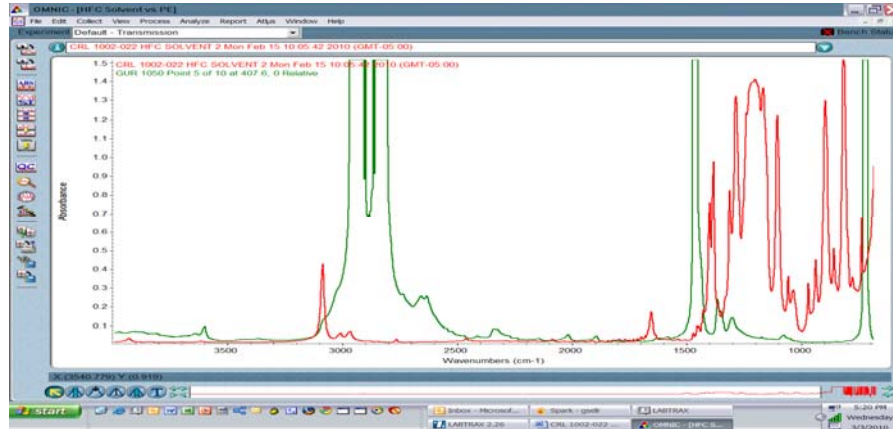


Table 1 describes some of the solvent processing conditions tested, the observed depths of solvent penetration into the UHMWPE, the desorption conditions used and the desorption test results.

Table 1
Samples of Tests and Results Using GUR 1050

Liquid Contact Time (Min.)	Vapor Contact Time (Min.)	Drying Time (Min.)	Drying Temperature (°C)	Drying Pressure (Atm.)	Solvent Absorbed (Y/N)	Maximum Depth (µm)
20		0	ambient	ambient	Y	200
20		40	ambient	ambient	Y	500
20		68	ambient	ambient	Y	600
20		0	ambient	ambient	Y	300
20		30	80/oven	ambient	Y	1000
20		60	80/oven	ambient	Y	1100
20		90	80/oven	ambient	N	N/A
20		120	80/oven	ambient	N	N/A

Conclusions: The results of this study indicated both solvents were quickly (within 2-5 minutes) absorbed into the UHMWPE to depths of about 1 mm, but desorbed from it much more slowly. Desorption may take several hours even at elevated temperatures and reduced pressures. The use of elevated drying temperatures caused the absorbed solvents to penetrate deeper into the UHMWPE before being desorbed.

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Breaking the Myth that Caustic Surgical Instrument Cleaners are Necessary for Safe and Effective Decontamination of Medical Devices

Marcia Frieze, Case Medical, South Hackensack, NJ

Green Chemistry is the design of chemical products and processes that reduce or eliminate the use or generation of hazardous substances. This approach to pollution prevention is the focus of the US Environmental Protection Agency's Green Chemistry Program.

It is our position that caustic detergents such as alkaline cleaners followed by acid neutralizers are unnecessary for instrument processing and present significant hazard to the waste water stream, to the devices to be cleaned, and result in safety issues for staff and patients. There are validated processes and products available that are pH neutral, environmentally friendly, and safer for human health and the environment with proven log reduction. We propose to present a study utilizing a three step process including enzymatic cleaners that demonstrates 6Log reduction under abbreviated cleaning conditions.

Cleaning is the critical first step performed in the sterile processing process of reusable medical and surgical devices. Ineffective cleaning of these devices can interfere with the effectiveness of subsequent sterilization or disinfection and increase the risk of nosocomial infection in patients and healthcare staff. Additionally, ineffective cleaning can affect the ability of medical devices to function properly and decrease the useful life of the devices, resulting in increased repair and replacement costs to the healthcare facility. Cleaning is defined as the removal, usually with detergent and water, of adherent visible soil such as blood, protein substances and other debris, from the surfaces, crevices, serrations, joints, and lumens of instruments, devices, and equipment by a manual or mechanical process that prepares the items for safe handling and/or further decontamination.

Worldwide industry is faced with the challenge to provide effective devices and products for surgical instrument cleaning and decontamination while recognizing the importance of sustainability and ecological compatibility. Sustainability has been defined as meeting the needs of the current generation without impacting the needs of future generations to meet their own needs. There is a social responsibility to protect the public from exposure to harm. As a result, all manufacturers need to anticipate and are obligated to design instrument chemistries to control measures which might lead to possible harm or uncertainty. The burden of proof that the suspected risk is not harmful falls on those taking action.



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The concept of the precautionary principle includes an ethical responsibility toward maintaining the integrity of natural systems, a willingness to take action in advance of definitive scientific proof when a delay will prove ultimately most costly to society and nature as well as unfair and ultimately selfish to future generations.

Cleaning, decontamination and subsequent sterilization are essential steps in breaking the chain of infection. Cleaning is the most critical step in the decontamination process and requires the commitment from the manufacturer to design and produce instrument chemistries with demonstrated efficacy and sustainability.

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SESSION 3: CLEANING AND TESTING, PART 2

Cleaning and Testing for Debris in Reusable Medical Devices

Shani Haugen, Vicki Hitchins, FDA, Silver Springs, MD

Residual organic material in reusable medical devices impedes proper sterilization, which can lead to outbreaks of infections. Thus, proper cleaning is an important first step in preparing a used reusable medical device for clinical use on the next patient. In the past, “visibly clean” was an acceptable endpoint for determining if a device was clean and ready for disinfection/sterilization. However, complex devices that have features such as narrow lumens, stopcocks, sheaths, acute angles, joints, or hinges are becoming increasingly common. Such design features are not readily visualized by the naked eye; therefore, “visibly clean” is no longer an acceptable endpoint for “clean”. Currently, there are several methods to detect residual debris on and within devices, however these methods are not optimized to detect insoluble clinical debris, such as tissue, cartilage, or bone. Unless the debris is completely digested or solubilized, such material may not be adequately sampled, and/or may not be accurately measured in a “cleaned” device.

To quantify insoluble debris, we have developed a filter-weighing approach to assess total residual debris in models of complex devices and actual medical devices. Briefly, after the device or model is inoculated with test soil and cleaned, the device is immersed in filtered water and agitated for two hours to extract debris. The extraction liquid is then filtered, and total debris on the filter is assessed. This method is simple, sensitive, and requires few pieces of specialized equipment. In some instances, the amount of protein in the extraction liquid was below the level of detection by the Bradford assay, however the filter-weighing approach was able to detect total debris (>100 micrograms). Additionally, the filtrate can be saved to assay for the presence of soluble protein, total organic carbon, etc. This method is flexible, and can be used with different devices, with different types of test soil, by manufacturers performing cleaning validation, or users who seek occasional verification of device cleanliness. Future experiments will use this assay to assess the impact of device design on retention of organic material in reusable medical devices.

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Evaluation of the Cleaning Efficiency of a Aqueous Based Detergent System for Cleaning Metallic Medical Devices

B. Dhanapal¹, N. Weiler¹ and J. Rufner², ¹Zimmer GmbH, Switzerland, ²Zimmer Inc, Warsaw, USA

Introduction: Cleaning orthopaedic implant devices commonly involves aqueous detergent based processes. The detergent solutions may be acidic, alkaline or neutral and ultrasonics may also be utilized. In this example system a series of baths using different detergents combination with sonication was used to evaluate the cleaning effectiveness for 100% metallic medical devices. Detergents of both alkaline and acidic nature were used for the removal of auxiliary processing materials used in the different manufacturing steps from the raw material to the final product (such as grinding, blasting, machining and others). This system utilized five consecutive baths. The first two baths contained alkaline detergents at different concentrations; the fourth bath was an acidic detergent. The third and fifth baths were rinse baths containing highly purified water to minimize the carry-over of the detergents to subsequent baths. The concentration of the detergents were monitored and closely controlled in order to insure the removal of auxiliary materials and the chemical cleanliness of the device. Periodic adjustment of the detergent concentrations was necessary to ensure optimum concentration and cleaning potential at all times within the life cycle of the detergent baths.

Monitoring Approach: According to literature published by the supplier of the detergents, the respective detergent concentrations could be determined by performing an acidimetric titration of the solution. An empirical factor is provided by the manufacturer to calculate the detergent concentration (v/v %) from the volume of Hydrochloric Acid or Sodium Hydroxide used in the titration. The weekly monitoring activities of the cleaning system were as follows:

- Sampling of baths No. 1, 2 and 4
- Acidimetric titration (colorimetric)
- Calculation of the difference between the current (measured) detergent concentration and the target concentration
- Based on the measured detergent concentration, addition of detergent as necessary to achieve the target concentration

The detergent baths are analyzed twice a week with regard to detergent concentration by acidimetric titration (direct monitoring). A calibrated automatic titrator was used (potentiometric titration) because this offered a higher accuracy and precision than visual titration techniques. After three full weeks of use, the detergent baths were completely renewed. This period defines the life cycle of the detergent baths.



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The test parts were assayed for Carbon Tetrachloride (CCl₄) extractable residues by FTIR, water extractable residues by Total Organic Carbon (TOC), and for water extractable insoluble particulate matter gravimetrically.

Evaluation of the Cleaning Efficiency: In order for this defined detergent bath life cycle to be validated, the product cleanliness was used to define the acceptance criteria. It was analyzed for pre-defined worst-case conditions in the cleaning system. Worst-case scenarios were defined by taking into account such things as: devices which possessed the most challenging size, surface texture, geometry etc, longest time period from bath renewal as well as from the detergent replenishment, and washing programs with the shortest dwell times, lowest ultrasonic power and lowest temperatures. After washing, the parts were removed from the system and analyzed using analytical methods.

Results: Three different worst-case devices were subjected to chemical cleanliness analyses (see Table 1). The following results were obtained:

Part Description & Characteristics	Chemical Cleanliness Prior to the Cleaning Step		Chemical Cleanliness After the Cleaning Step	
	Average in mg/ Part	Max Value in mg/ Part	Average in mg/ Part	Max Value in mg/ Part
Hip Cup / Challenging Surface	Organic Residue: 5.9 TOC: 0.21 Ionic Residue: 1.24 Particulate Residue: 15.7	Organic Residue: 6.0 TOC: 0.22 Ionic Residue: 1.30 Particulate Residue: 23.6	Organic Residue:<0.5 TOC: 0.07 Ionic Residue: 0.07 Particulate Residue: 0.6	Organic Residue:<0.5 TOC: 0.08 Ionic Residue: 0.08 Particulate Residue: 0.8
Hip Stem / High Production Rate, Challenging Geometry	Organic Residue:<0.5 TOC: 0.09 Ionic Residue: 0.14 Particulate Residue: 2.9	Organic Residue:<0.5 TOC: 0.11 Ionic Residue: 0.19 Particulate Residue: 3.7	Organic Residue:<0.5 TOC: 0.05 Ionic Residue: <0.05 Particulate Residue:<0.2	Organic Residue:<0.5 TOC: 0.06 Ionic Residue: <0.05 Particulate Residue:<0.2
Femur Component / Highly porous surface	Organic Residue: 2.6 TOC: <0.05 Ionic Residue: 0.09 Particulate Residue: 0.4	Organic Residue: 2.9 TOC: <0.05 Ionic Residue: 0.09 Particulate Residue: 0.4	Organic Residue:<0.5 TOC: <0.05 Ionic Residue:<0.05 Particulate Residue:<0.2	Organic Residue:<0.5 TOC: <0.05 Ionic Residue:<0.05 Particulate Residue:<0.2

Table 1: Average Results: Total Organic Carbon (TOC), Organic Residual, Ionic Residual, Particulate Residual



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Total of 135 specimens were analyzed in the scope of this cleaning validation.

Discussion: During the direct monitoring of the detergent concentrations using potentiometric titrations, a significant drop in detergent concentration of up to 20 %(v/v) within a week was observed. Thus, the detergents were replenished twice a week to keep the concentrations within the specified limits. Using these standardized cleaning processes enabled us to obtain clean products in a reproducible and repeatable manner.

Conclusions: From the results shown in Table 1 for the predefined worst-case parts and worst-case conditions in terms of cleaning parameters, it is clear the system and operational parameters described were able to produce parts with very small amounts of chemical residuals.

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Two-phase Flow Cleaning of Endoscope Channels

Mohamed E. Labib¹, Stanislav Dukhin¹, Joseph Murawski¹, Yacoob Tabani¹, Richard Lai¹ and Michelle Alfa²

¹Novaflux Technologies, Princeton, NJ 08540, USA, ²St. Boniface General Hospital, Winnipeg, MB R2H 2A6, Canada

Cleaning of flexible endoscopes has been traditionally done by flowing a cleaning liquid through endoscope channels. Because of the small diameter of the narrow lumens of flexible endoscopes, the magnitude of bulk shear created during liquid flow is low and the cleaning efficiency is usually limited. This is why manual cleaning is recommended before processing the endoscope in conventional AERs.

During our investigation of two-phase flow in hydrophobic narrow channels, we discovered a new hydrodynamic mode that can create shear stress orders of magnitude higher than the bulk shear generated by conventional liquid flow. This hydrodynamic mode was investigated in long Teflon tubes (about 200 cm) and in endoscopes, in the range of Reynolds number 6,000 to 30,000 at different water/air volumetric ratios (WAVR). High-speed video-microscopy techniques have allowed us to visualize a new mechanism of flow instabilities in endoscope channels. We were able to compare the cleaning of such channels with the two-phase flow and with conventional liquid flow.

We will review and analyze the fundamentals of cleaning long and narrow lumens with emphasis on flexible endoscopes. We will also discuss critical issues involved in removing macromolecules such as proteins and adhering organisms from the surface of endoscope channels. We will place emphasis on the novel two-phase flow process.



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Assessment of Organic Residues on Medical Devices

B. Dhanapal¹, D. Zurbrugg,² J. Rufner³, R. Gsell⁴, ¹ Zimmer GmbH, Switzerland, ² Niutec AG, Switzerland, ³ Zimmer Inc, Warsaw, IN, USA,

Introduction: Although governmental agencies currently have not set limit values for residues on orthopaedic implant devices, it is the manufacturer's responsibility to provide clean, safe and effective products. They must develop appropriate test methods and specify acceptance criteria. Currently ASTM F 2459–05¹ is the only standard published which was developed specifically for medical implant devices. It is limited to metallic devices using gravimetric quantification. A second medical implant cleanliness guide is being developed under ASTM WK15532². This guide describes a wide range of more specific and sensitive test methods for assessing implant cleanliness.

Methods: Fourier Transform Infrared spectroscopy (FTIR) method has been used to quantify the amount of carbon tetrachloride (CCl₄) extractable residues on 100% metallic devices. The sum of organic residues is quantified against a calibration curve prepared using a hydrocarbon reference standard such as hexadecane. Other reference materials, such as known manufacturing lubricants, may also be used. The FTIR technique is widely used for the quantification of organic residues in different fields like e.g. ASTM 1374-92(2005)³.

The test device is extracted with CCl₄ to dissolve the residues. The amount of organic material present in the resulting extract solution is then quantified (e.g., as mg equivalent of hexadecane per part) by measuring its maximum absorbance in the 2800-3000 cm⁻¹ region. Using the appropriate calibration curve the absorbance readings are converted to extract solution concentrations and finally to mg/part readings.

Discussion: Based on our experience using ASTM F 2459–05¹ to quantify residuals gravimetrically the typical detection limit for soluble residues of 0.3 mg/part is more than a factor ten (0.02 mg/part) higher than the FTIR method describe here. Lower limit of detection (LOD) may be necessary to statistically assure a reliable assessment of the cleanliness of certain products.

Using one or more of the specific methods proposed by WK15532² may be of benefit too. For example, it may be possible to use techniques such as gas chromatography (GC) coupled with mass spectroscopy detection (MS), high-performance liquid chromatography (HPLC) coupled with such detector systems as MS, single or multi-channel or photo diode array ultraviolet (UV) detector systems or evaporative light scattering detection (ELSD).



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In some cases it is possible to not only quantify the total amount of extractable organic residue but to identify and quantify the specific components from specific lubricant and detergent systems used.

Based on our experience these techniques (e.g. ASTM F 2459–05¹ and FTIR) can also be applied to polymeric medical devices. However, one has to consider that the polymer itself might release materials which are by definition not residues. Such materials that are already present in the raw material must be considered when setting the extraction and analytical parameters and their acceptance criteria.

Conclusion: Although ASTM F 2459–05¹ has made a significant contribution to the orthopaedic industry in regards to evaluating the cleanliness of 100% metallic medical devices, more standardization is needed in application of the many different techniques available to the analyst. Additionally, application of these techniques to the many different types of polymeric materials used by the industry presents another major challenge. To assure the safety of the medical devices, their cleanliness using sensitive methods as proposed here and by ASTM F 2459-05¹ WK15532² are necessary.

Reference

- [1] ASTM F 2459–05 Standard Test Method for Residue from Metallic Medical Components and Quantifying via Gravimetric Analysis
- [2] ASTM Work Item: WK15532 - New Practice for Reporting and Assessment of Residues on Single-Use Implants
- [3] ASTM 1374-92(2005) Standard Test Method for Ionic/Organic Extractables of Internal Surfaces- IC/GC/FTIR for Gas Distribution System Components (Ultra-High-Purity Gas Distribution Systems)

Presentation Slides



SESSION 4: ESTABLISHING CLEANING LIMITS

Establishing and Justifying Limit Values for Residual Analysis

Kierstan Andrascik, QVET Consulting, Layton, UT

There are no established regulatory limits for residual analysis. The primary reason for this is due to the number of variables involved. Every contaminant has differing degrees of toxicity, and that toxicity can change depending on where and how long it is exposed to the patient. Therefore, regulatory agencies have left it up to individual companies to establish and justify residue limits.

Probably the most common technique used to justify residue limits is performing biocompatibility testing. Demonstrating the biocompatibility of the clean devices shows that residues on that clean device are also biocompatible. Cytotoxicity and other biocompatibility tests are performed based on where and how long the device is exposed to the patient.

Other tests that may be beneficial to perform are endotoxin and bioburden. These tests would only be necessary if you wish to claim that the cleaning process reduces endotoxin or bioburden levels.

Another common technique for establishing and justifying residue limits is through comparison. Once all of the data has been collected concerning the residue amounts on the devices, various statistical calculations can be performed to establish residue limits. Clean samples from within a cleaning run can be compared to each other to confirm uniformity in a single cleaning run. Clean samples from multiple cleaning runs can be compared to demonstrate consistency from run to run.

When the cleaning process being validated has been established for a while, there is usually inventory available that was cleaned months or years before. These "off the shelf" devices can be analyzed to establish baseline data and compared to freshly cleaned devices. Since these devices have a history of non-problematic patient use, an appropriate acceptance criteria is that the amount of residue on the freshly clean devices needs to be the same or less than the corresponding "off the shelf" devices.

Another technique is a risk-based assessment which would include data concerning where patient exposure occurs and for how long. The risk of the detected residue amounts may be evaluated using available LD50 data for the target contaminants. Other available toxicity data can also be used (i.e. TDLO). Of course this data may not be readily available due to the proprietary nature of many manufacturing and cleaning materials.



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Limits need to be justifiable, but it is nice to have some wiggle room. Once a limit is established, it is much easier to justify lowering the limit than it is raising the limit. Regardless of what technique is used, regulatory agencies expect that limit values will be set for residual analysis.

Presentation Slides



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Residual Soil on Reusable Medical Devices: How to Determine Limits?

Steve Goldstein, Steve Goldstein Consultants, Albuquerque, NM

Cleaning reusable medical devices has become one of the most controversial reprocessing issues. While the need to remove foreign material before further processing is widely acknowledged, there has been a great deal of controversy regarding the amount of residual soil that would be permissible. Various standards organizations have been reviewing studies, examining data and in some cases facilitating new research in an effort to gain insight into how to best test for and define acceptable limits for residual soil.

The contemporary concern about cleaning reusable devices can be traced back to a Technical Information Report published by the Association for the Advancement of Medical Instrumentation (AAMI) in 1993 entitled, "Designing, testing and labeling reusable medical devices for reprocessing in health care facilities: A guide for device manufacturers" (1994). This document then became the basis for the subsequent FDA publication, "Labeling reusable medical devices for reprocessing in health care facilities" (1996). Both documents emphasized the importance of cleaning, the FDA requiring that "All reprocessing instructions include a statement that the device must be thoroughly cleaned." and that the manufacturer "...evaluate the rigor of the cleaning process in terms of how adequate the process will be in eliminating visible soil from the device to make the device patient ready".

After publication of the FDA Labeling Guidance, European regulators mandated that standards be developed for medical devices sold in Europe. CEN (European Committee for Standardization) and ISO ([International Organization for Standardization](#)) committees began to develop standards for washer-disinfectors in 1996-1997, which included a substantial effort to move beyond "visibly clean" as a measure of cleanliness. They attempted to identify appropriate soils, test methods, and endpoints for cleanliness of reusable medical devices processed in washer-disinfectors. A cleaning document produced through this collaboration required a number of years to develop and yet agreement on a single or limited number of tests and endpoints was not possible. Rather, the collaborating committees published a list of national cleaning tests used by various member countries (Washer-disinfectors - Part 5: Test soils and methods for demonstrating cleaning efficacy of washer-disinfectors. ISO/TS 15883-5:2005). Although this collection of 19 test methods is very valuable (it does include an ASTM Standard Test Method), an ongoing effort by ISO and CEN is now re-focused on defining and validating a more limited number of test method(s) for washer-disinfectors.



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This international effort has spawned a number of published works on both automated and manual cleaning and AAMI has published a compendium of these works entitled, "A compendium of processes, materials, test methods, and acceptance criteria for cleaning reusable medical devices" (2003). This document is currently being updated and revised. However, research into cleaning reusable medical devices still represents a relatively small body of work and the standards community looks to the ISO-CEN group to continue their efforts to develop validation schemes for automated cleaning devices and hopes that their work will be easily transferrable to manual cleaning. The next challenge will be to identify a reliable means of verifying cleanliness that can be used at reprocessing sites.

Presentation Slides



Workshop on Medical Device Cleanliness: How Clean is Clean Enough?

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Workshop on Medical Device Cleanliness: How Clean is Clean Enough?

Stephen Spiegelberg



**Cambridge
Polymer Group, INC.**

Consultation, Testing, and Instrumentation for Polymeric Materials

Why do we clean?

- Healthcare-associated infections*
 - 2 million infections
 - 90,000 deaths
 - \$4.5 Billion in excess health care costs
- Single use and reusable devices
 - Manufacturing residues
 - Cleaning agents
 - Bacteria
 - Endotoxins
- FDA Recalls
 - FDA has launched 64 recall for medical devices within the last 7 years among them are 26 due to process contamination

*Weinstein, Emerg Infect Dis, 1998



Workshop on Medical Device Cleanliness: How Clean is Clean Enough?

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A corollary to the 2nd law of thermodynamics

IMBESI'S LAW OF THE CONSERVATION OF FILTH*

“Whenever something becomes clean, something else becomes dirty.”

Cleaning is the process of moving residues from one location to another

* Ken Kesey, “One flew over the cuckoo’s nest”

Four Laws of Cleaning

1. Whenever something becomes clean, something else becomes dirty
2. Soil is like entropy—never destroyed, always created
3. One can never get something completely clean
4. To get a particle off a surface, first you have to find both

cleaning is soil management

John Durkee “Management of Industrial Cleaning Technology and Processes”

Design to Minimize Cleaning

- Design components for simple, effective cleaning
 - Blind spots
 - Mixed materials
 - Sharp corners, fine features
- Design components for simple manufacturing
 - Fewest manufacturing steps
 - Fewest number of processing compounds (grit blast, polish, masking)
- Design simplest cleaning operation
 - Omnidirectional cleaning vs. directional
 - Avoiding redepositing removed soil on clean parts
 - Cleaning your clean-line
 - Cross-contamination of different components cleaned in the same clean-line
- Design with cleaning validation in mind
 - How to assess how clean your parts are?

Challenges of Cleaning

- Adequate removal of soils without introducing new residues
 - Cleaning agents
 - Migration of residues from one location to another
 - Elution/extraction
- Damage to component
 - Mechanical, thermal, chemical
- Validation of cleaning process
- Cost and process time



Workshop on Medical Device Cleanliness: How Clean is Clean Enough?

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ASTM Activities in Device Cleanliness (F04.15.17)

- Workshop on Device Cleanliness (May, 2003)
- Symposium on Device Cleanliness (May, 2005)
- Passed first standard on assessing cleanliness (ASTM F2459-05)
- WK15532: Guide for Assessment of Contamination and Residues on Medical devices
 - Compilation of known assays for residues, including endotoxins
- WK13292: Standard Practice/Guide for Shipping Possibly Infectious Materials, Tissues, and Fluids

Upcoming Topics

- Cleaning and analysis methods
- Cleaning reusable devices
 - Endoscopes
 - Cannula
 - Arthroscopic shavers
- Establishing cleanliness limits

Reusable Devices

- Exposure of components to tissue and fluids
- Cleaning and disinfection require access to surfaces
 - Design for disassembly and cleaning
- Adequate instructions for reprocessing
 - Potential damage to component during cleaning
 - How many times can it be reprocessed?

How Clean is Clean Enough?





Fact Finding: Ongoing Safety Review of Arthroscopic Shavers and Suction Tips

University of Michigan



Jahan Azizi, Clinical Engineer Risk Management Consultant



Arthroscopic Shaver





Ongoing Safety Review of Arthroscopic Shavers

The FDA has become aware of events in which tissue has remained within certain arthroscopic shavers, even after the cleaning process was believed to have been completed according to the manufacturer's instructions.

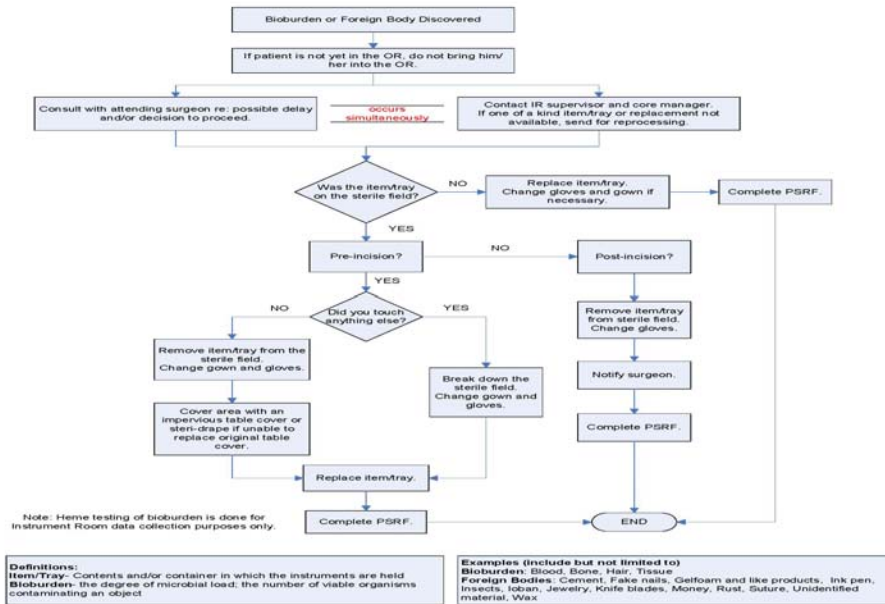
Reports submitted to the FDA suggested that the tissue retained was not evident to the naked eye. Multiple manufacturers of these devices recently informed their customers of this situation and reiterated the importance of proper cleaning procedures.



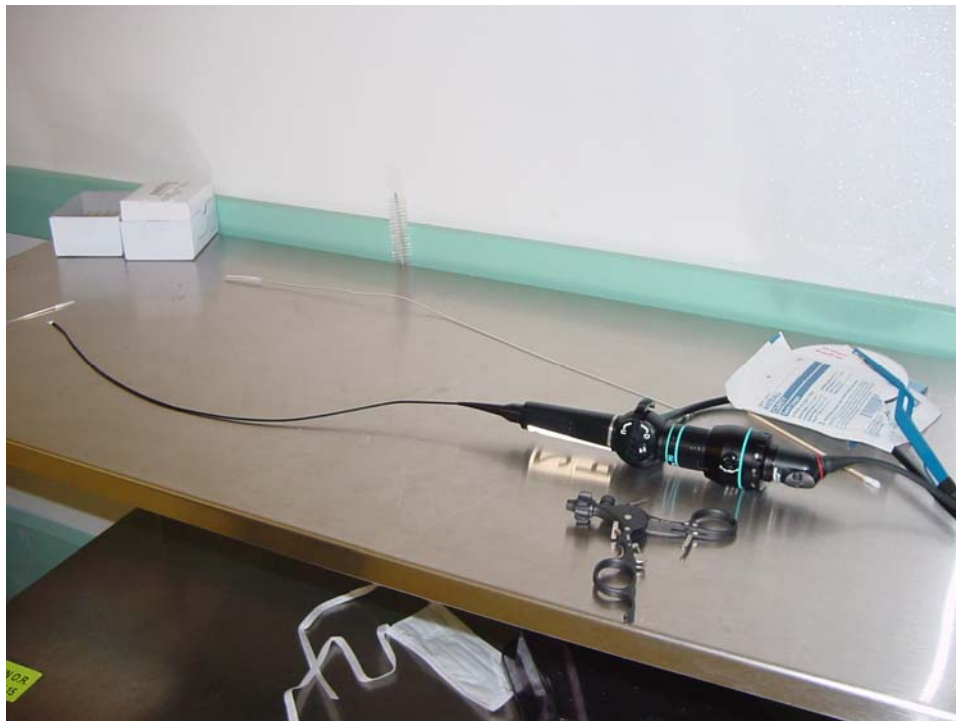
Examples (include but not limited to)

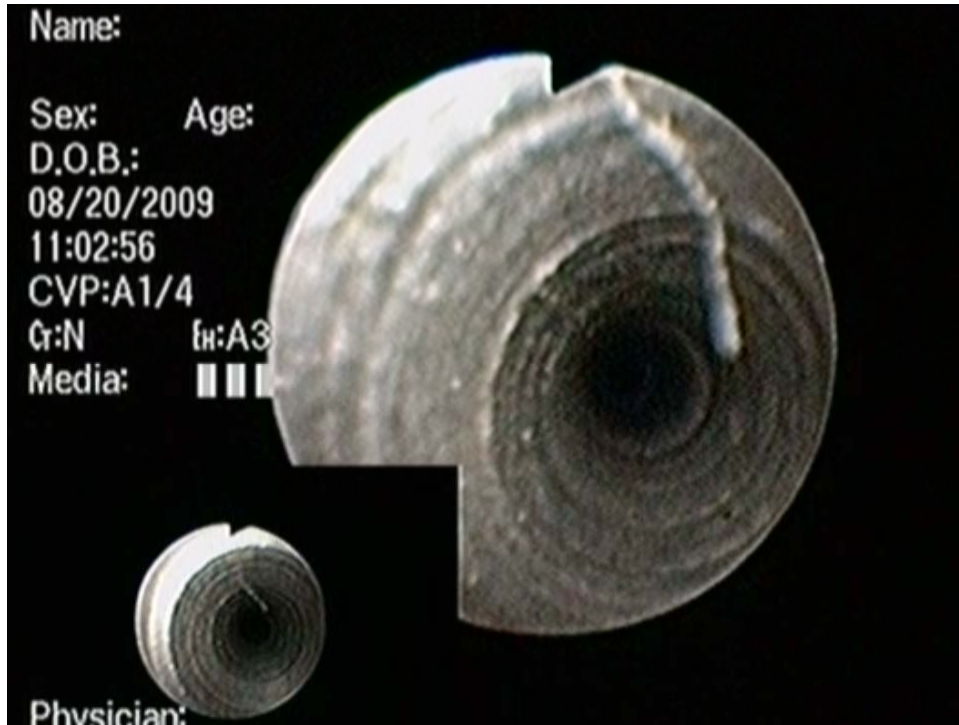
- **Bioburden:**
 - Blood, Bone, TissueANSI/AAMI/ISO TIR11139:2006 as "population of viable microorganisms on or in product and/or sterile barrier system".
- **Foreign Bodies (debris):**
 - Bone cement, artificial nails, Gelfoam™ and like products, ink pens/pencils, insects, Ioban™, jewelry, knife blades, coins, rust, suture, unidentified material, bone wax

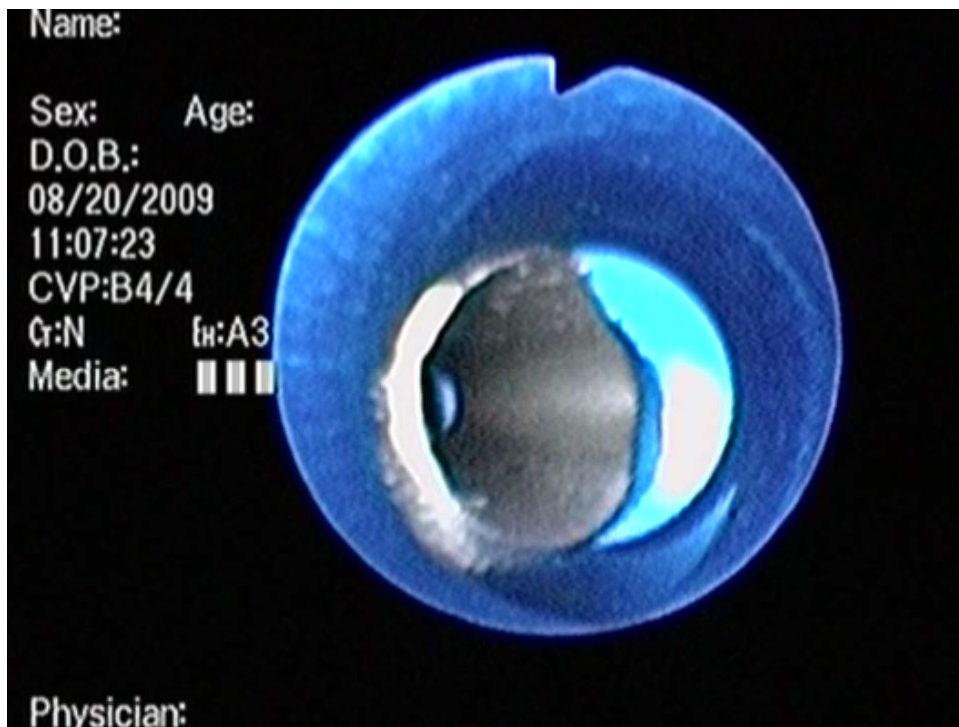
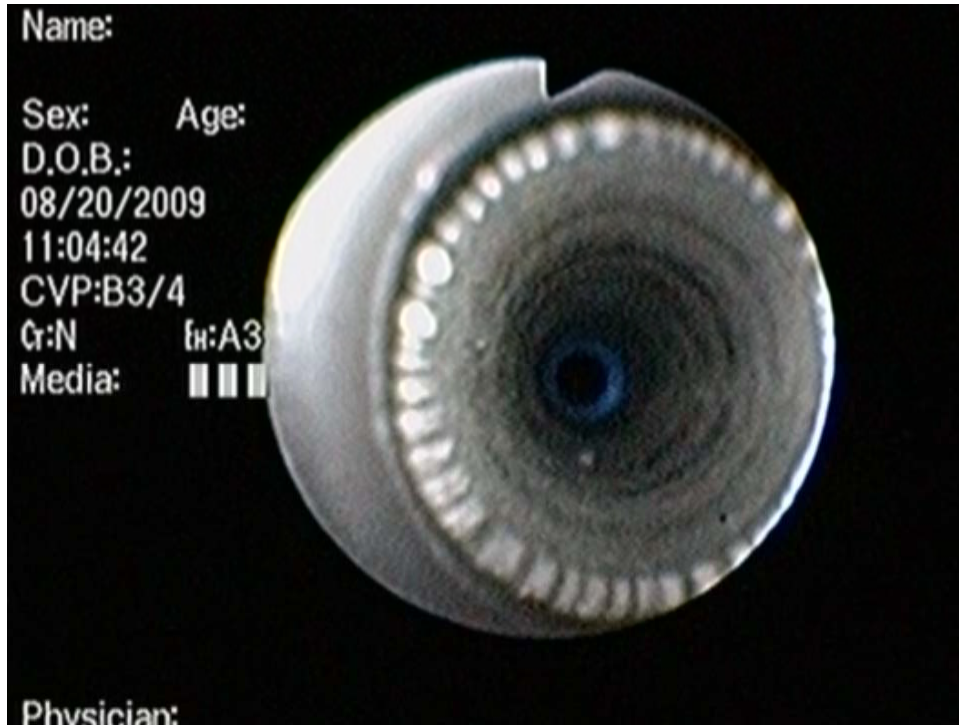
MANAGEMENT OF BIOBURDEN AND FOREIGN BODIES

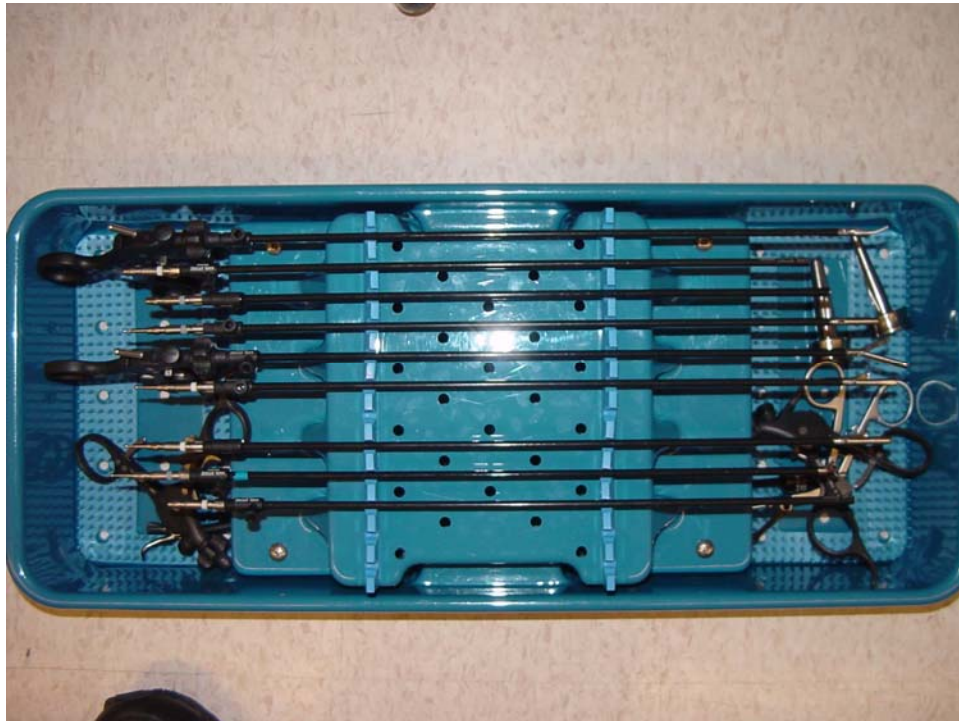


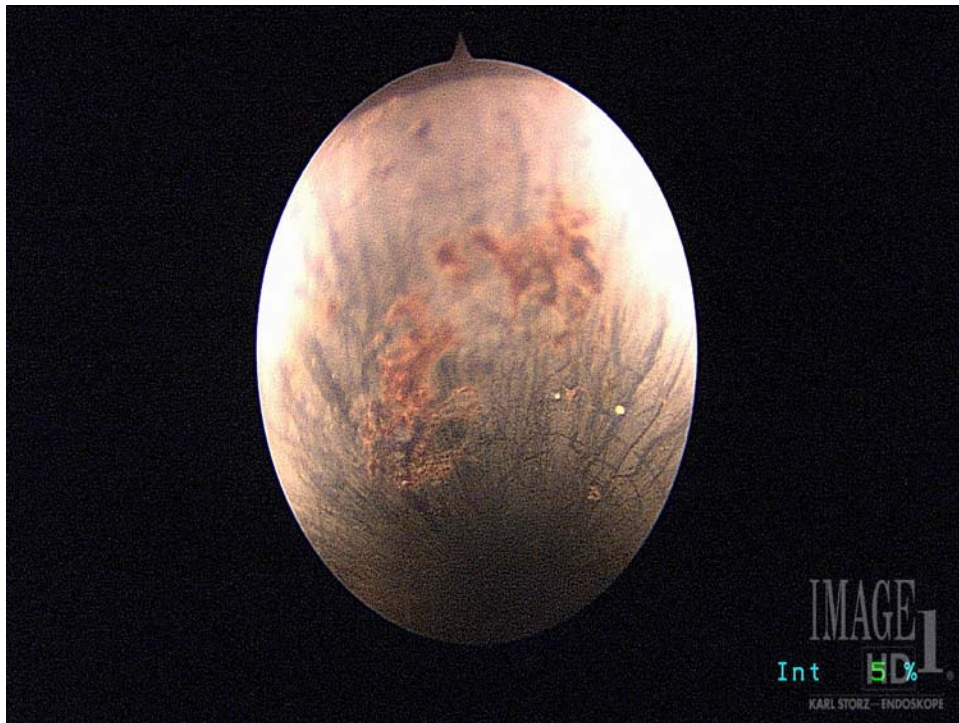
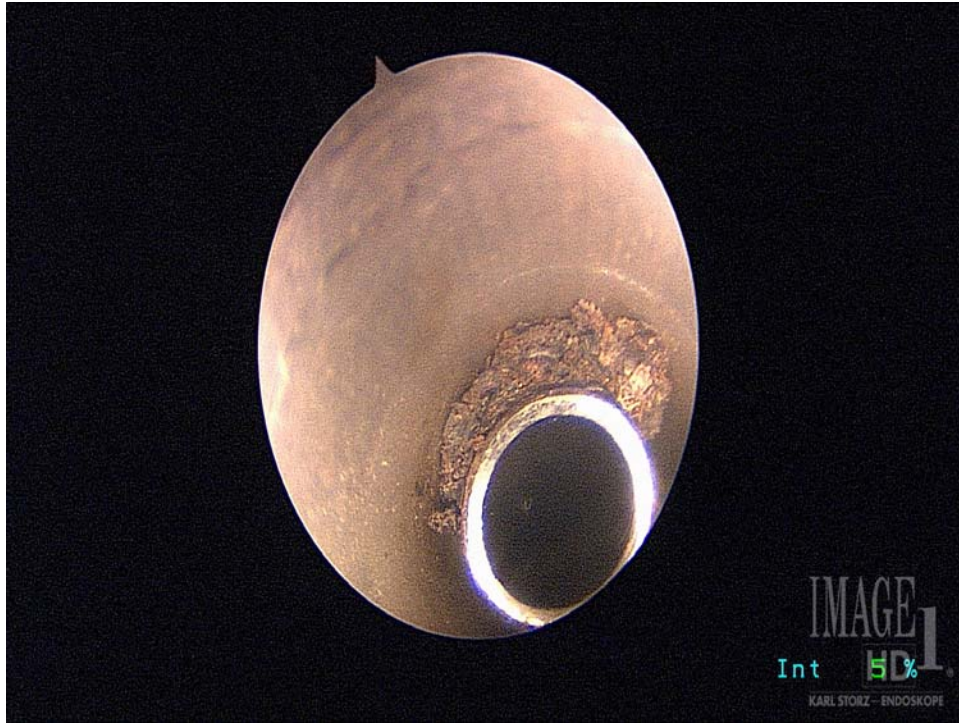
Management of Bioburden flowchart7.vsd/5/15/2009
 UH-OR Lisa Sturm, Marc Finch



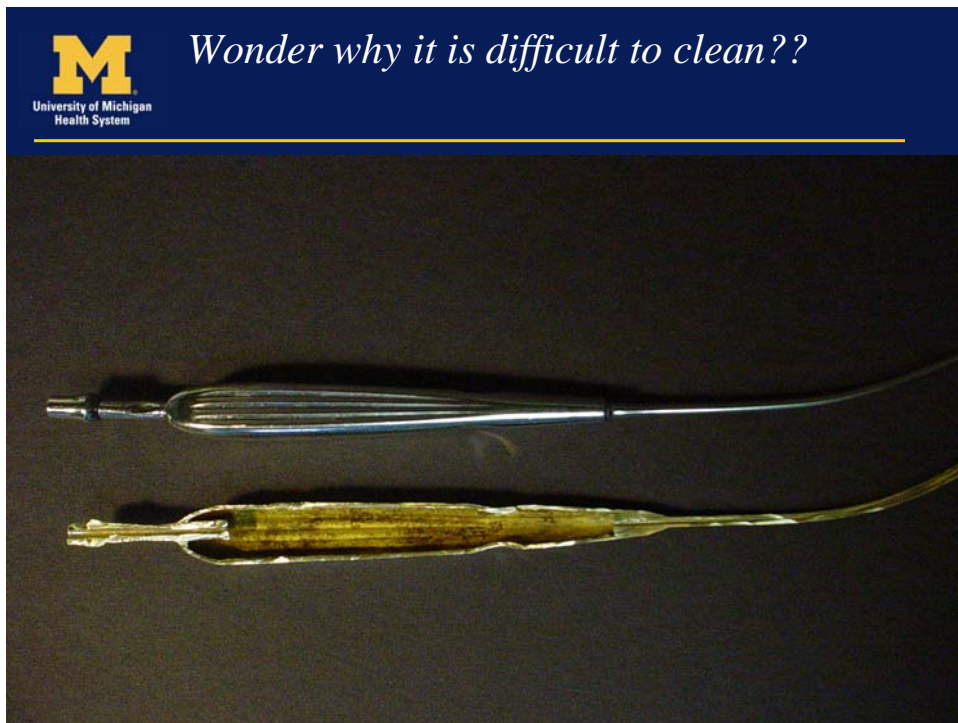
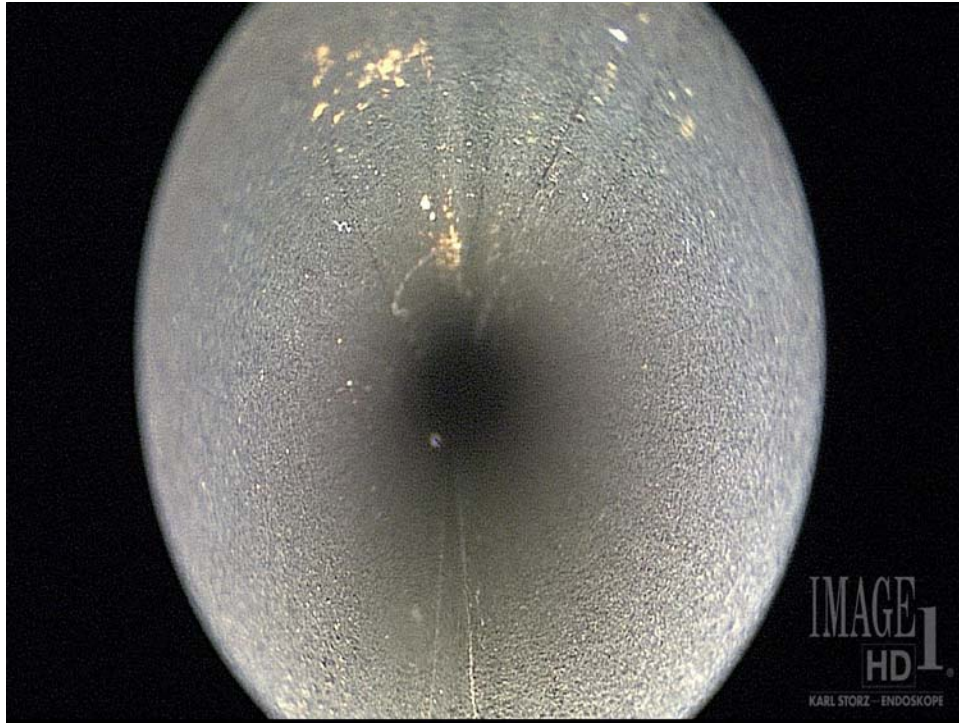












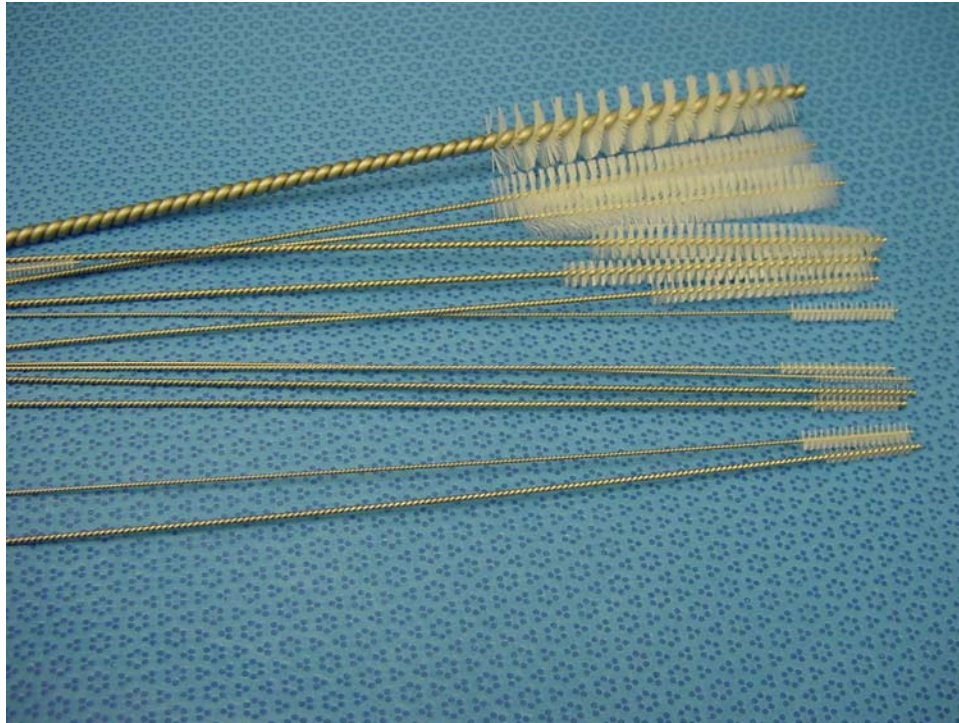


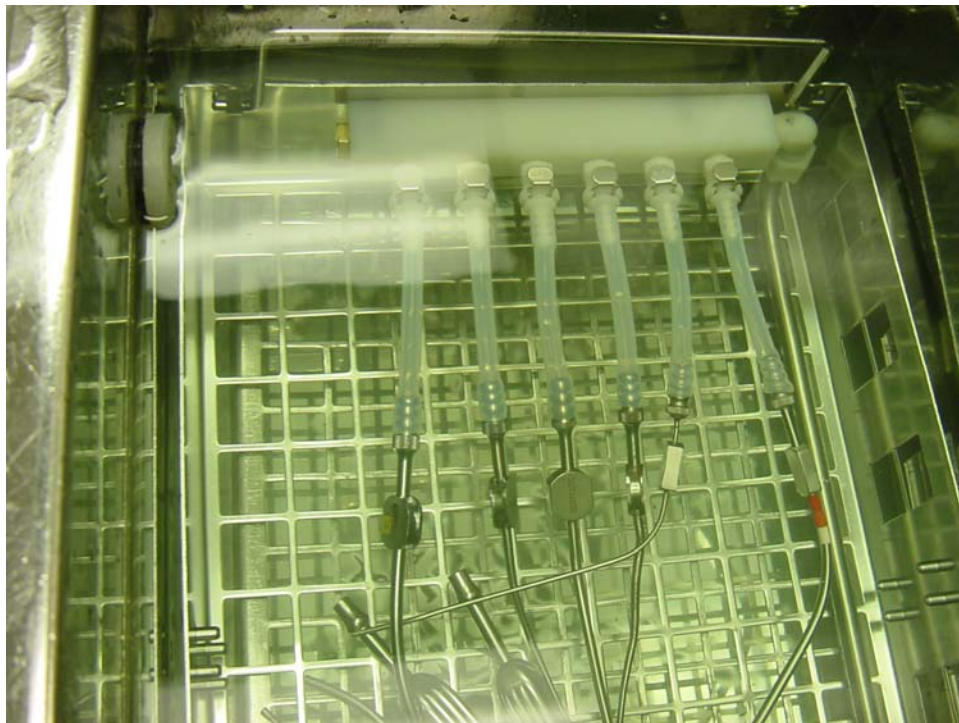
University of Michigan
Health System

Problematic Instrumentation

- Septorhinoplasty set due to all the cannulas
- Coronary suctions due to the strange shape of the cannula
- All Ear trays, suctions and the very fine delicate instrments.
- Gastrosopes, Bronchoscopes, etc...
- Defibrillator. Paddles
- Lenses
- Trivex System
- Drills & saws
- Gamma nail sets
- Extract All set
- Kerrison Rongeurs
- Spring loaded drill guides
- flexible scopes
- Bipolar forceps with delicate tips
- Tympanomastoid set
- Kerrisons
- Orthopedic reamers





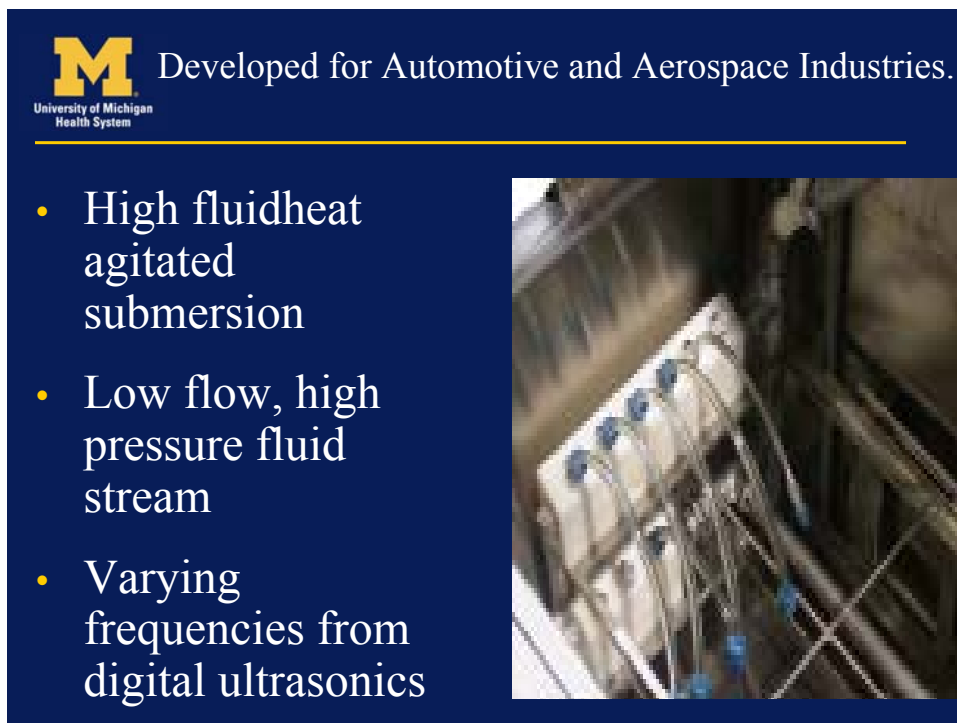
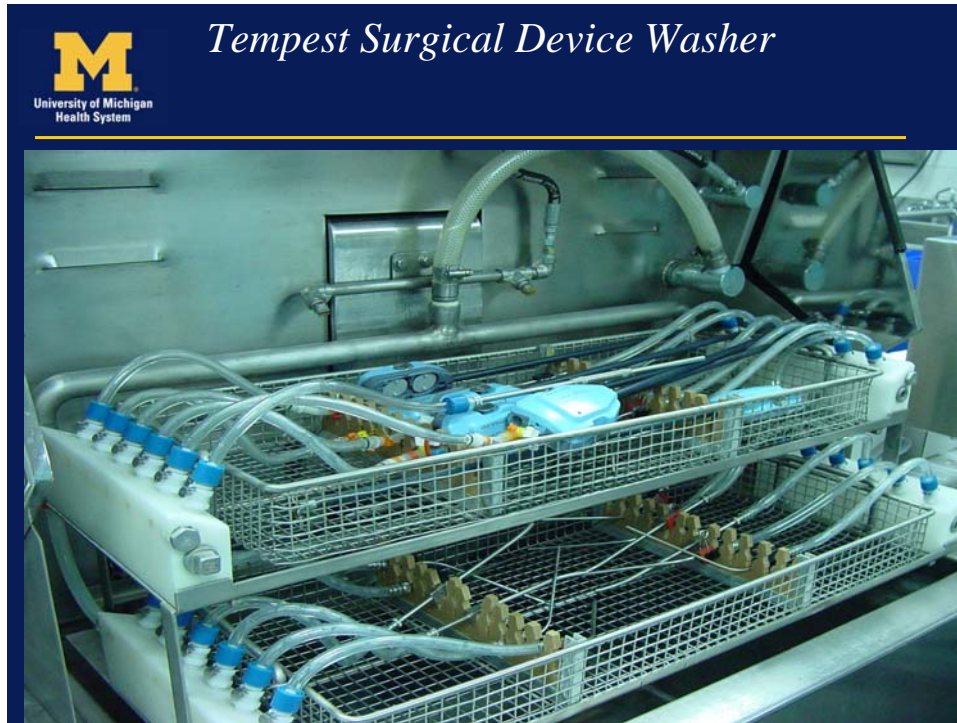




Next Step

- The Tempest™ Surgical Instrument Washer is a fully automated, single operator cleaning system designed for the Central Processing Department of Hospitals.
- Industrial strength design
- A proven cleaning process developed from more than 30 years experience as a leader in the automotive and aerospace industries, the Tempest™ brings more horsepower to cleaning all surgical devices than any other system previously available to the market.





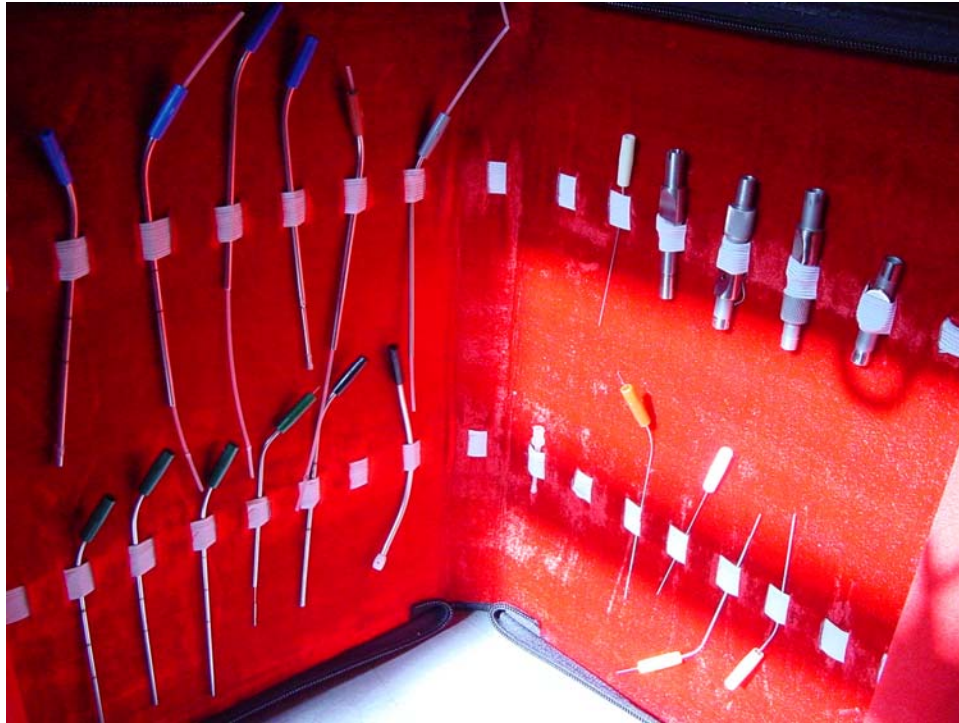
M
University of Michigan
Health System

Developed for Automotive and Aerospace Industries.

- High fluidheat agitated submersion
- Low flow, high pressure fluid stream
- Varying frequencies from digital ultrasonics

A close-up photograph of the interior of the Tempest Surgical Device Washer, showing the wire mesh baskets and the surgical instruments being cleaned. The machine is filled with water and the instruments are being agitated.





Questions?

Jahan Azizi: azizi@umich.edu

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Your Vision, Our Future

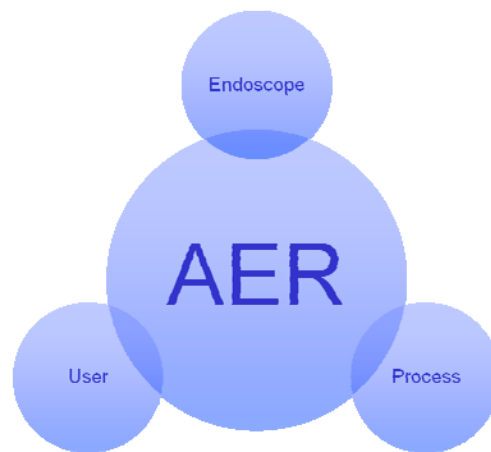
Validation Strategy for an Automated Endoscope Reprocessor

November 16, 2010

Bradley Catalone

AER Validation Strategy

System Approach



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AER Validation Strategy

- AER
 - ▶ Scope-specific connectors
 - ▶ Requires prior manual cleaning
- User
 - ▶ High turnover
 - ▶ Resource and time constraints
- Endoscope
 - ▶ Complex, multiple designs, new models consistently introduced
- Process
 - ▶ Multiple steps
 - ▶ Manual cleaning
 - ▶ Device-specific adapters

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Validation Objectives

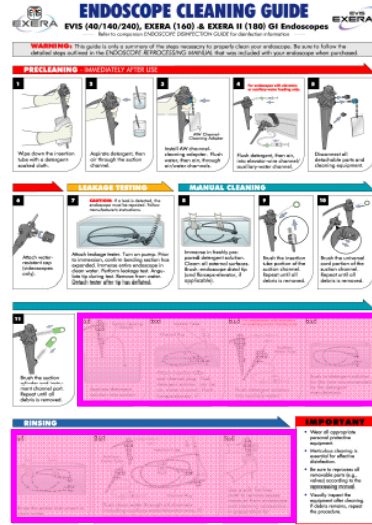
- Reduce manual steps
- Eliminate scope-specific adapters during manual cleaning
- Eliminate manual channel flushing
- Improve other cumbersome or unnecessary steps (eliminate bedside flush with detergent, reduce manual flush volumes, etc.)
 - ✓ Reduces variability
 - ✓ Less user dependent
 - ✓ Improves compliance with instructions



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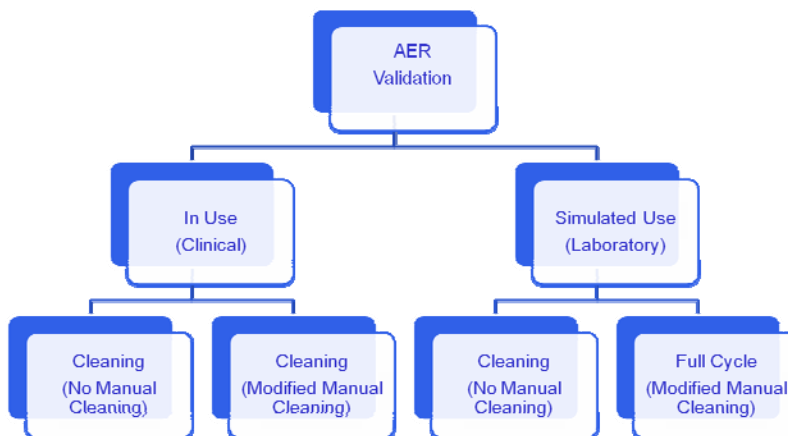
Modified Cleaning

- AER automates channel flushing
 - External surface cleaning and channel brushing required
-
- ✓ Reduces manual steps
 - ✓ Reduces labor
 - ✓ Improves efficiency
 - ✓ Improves compliance
 - ✓ Improves consistency



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AER Validation Design



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AER Validation Strategy

Simulated Use Testing

- Worst case for identified variables related to process efficacy
- Specific user-dependent steps not performed for testing

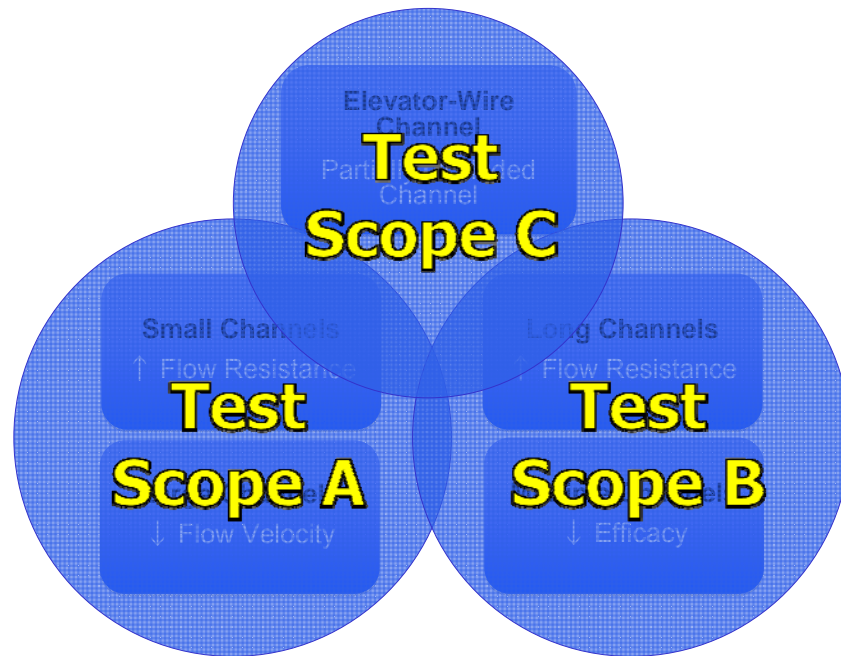
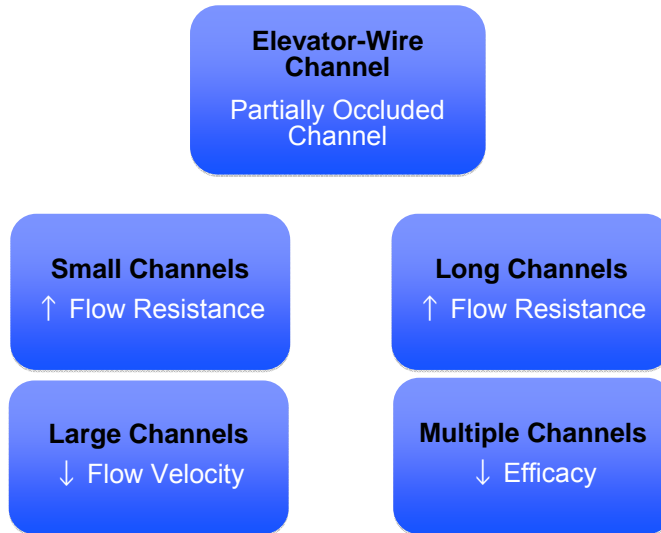
In Use (Clinical) Testing

- Validate efficacy in clinical environment according to AER IFUs
- Repeat validation eliminating specific user-dependent steps

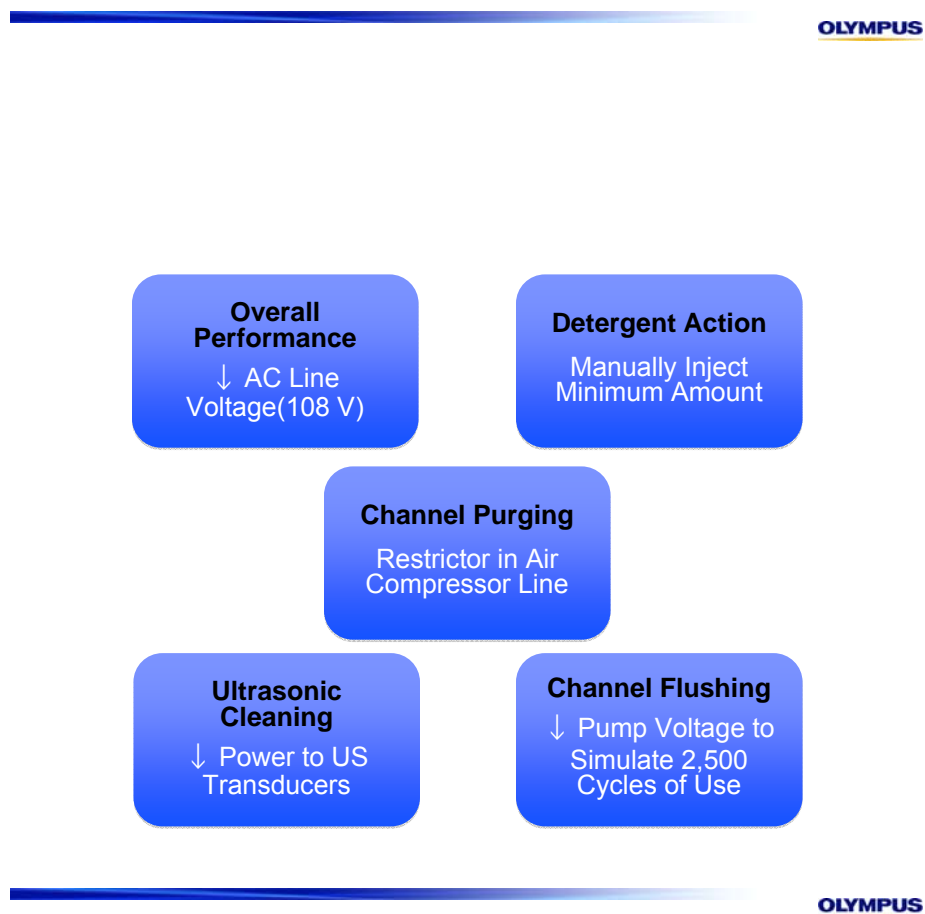
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**Panel of Test Endoscopes
to represent all
Olympus Endoscope
Models**

OLYMPUS



Worst-Case Conditions for the AER



**Worst-Case
Conditions for the
AER**

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**Worst-Case Conditions
for the Process**

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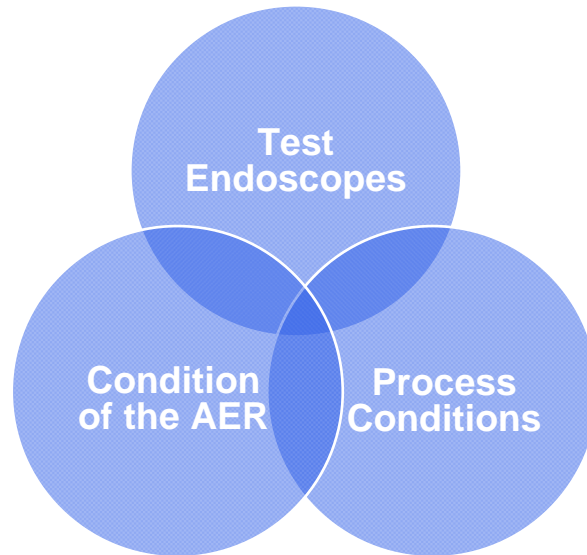


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**Worst-Case
Process**

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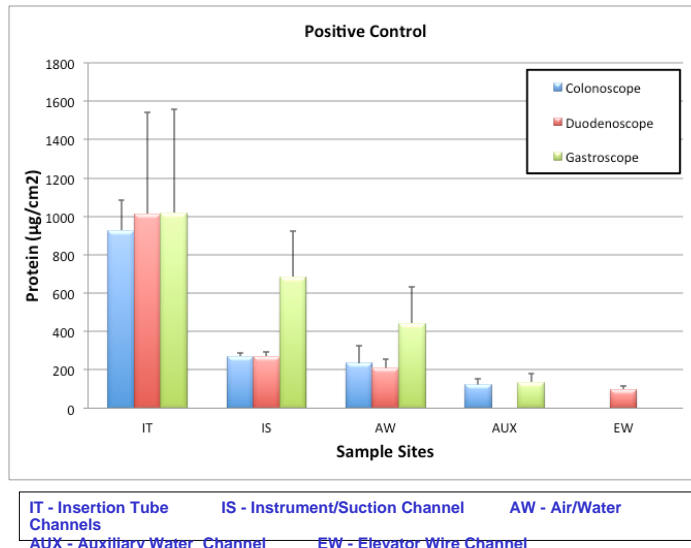


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		Simulated Use	Simulated Use	Clinical Use	Clinical Use
AER	Soil	ATS	ATS	Patient	Patient
	Pre-Clean				
	Manual Clean				
	Clean				
	Rinse				
	HLD				
	Rinse				
	Alcohol				

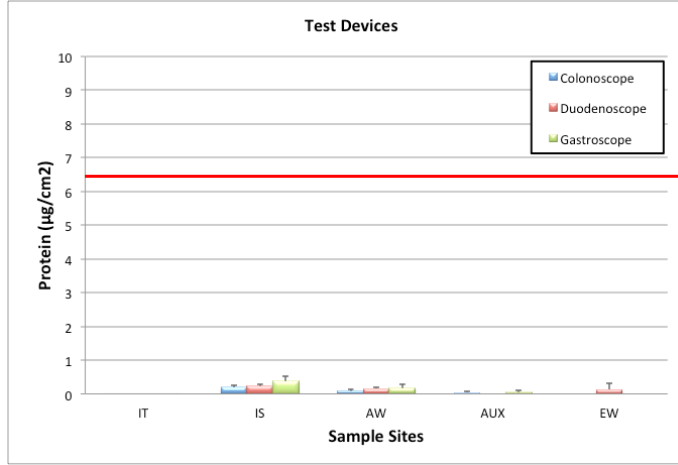
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Simulated Use Cleaning



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Simulated Use Cleaning

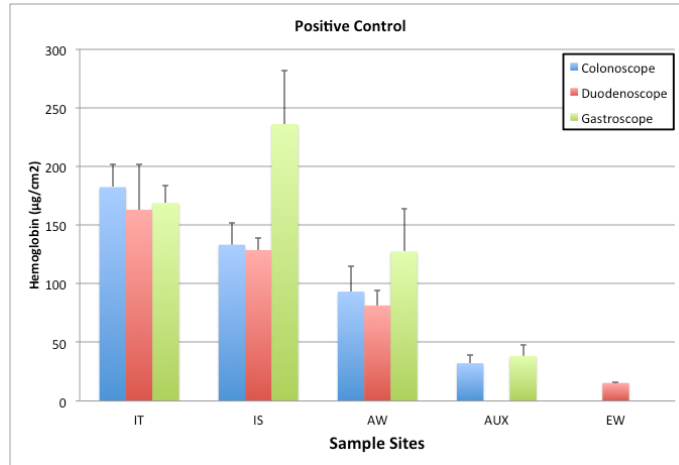


6.4 µg/cm²

IT - Insertion Tube Channels IS - Instrument/Suction Channel AW - Air/Water Channel
AUX - Auxiliary Water Channel EW - Elevator Wire Channel

OLYMPUS

Simulated Use Cleaning



Test Devices
•<LOD

IT - Insertion Tube Channels IS - Instrument/Suction Channel AW - Air/Water Channel
AUX - Auxiliary Water Channel EW - Elevator Wire Channel

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In Use - Cleaning



- **Endpoints**
 - **Protein:** < 6.4 $\mu\text{g}/\text{cm}^2$
 - **Bioburden:** < 4 Log_{10} CFU/cm²
- **15 Endoscopes, 65 Samples**
- **Bronchoscope, Colonoscopes, Duodenoscopes**
- **Results**

	Protein ($\mu\text{g}/\text{cm}^2$)	Bioburden (Log_{10} CFU/cm ²)
Bronchoscopes	<LOD – 0.55	0 - 0.016
Colonoscopes	<LOD – 0.60	0 - 0.005
Duodenoscopes	<LOD – 0.62	0 - 0.050

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In Use - Cleaning

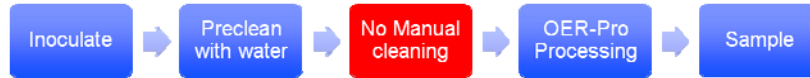


- **Endpoints**
 - **Protein:** < 6.4 $\mu\text{g}/\text{cm}^2$
 - **Hemoglobin:** < 1.8 $\mu\text{g}/\text{cm}^2$
- **14 endoscopes, 62 samples**
- **Bronchoscope, Colonoscopes, Duodenoscopes**
- **Results**

	Protein ($\mu\text{g}/\text{cm}^2$)	Hemoglobin ($\mu\text{g}/\text{cm}^2$)
Bronchoscopes	<LOD – 1.39	<LOD
Colonoscopes	<LOD – 4.33	<LOD
Duodenoscopes	<LOD – 0.88	<LOD

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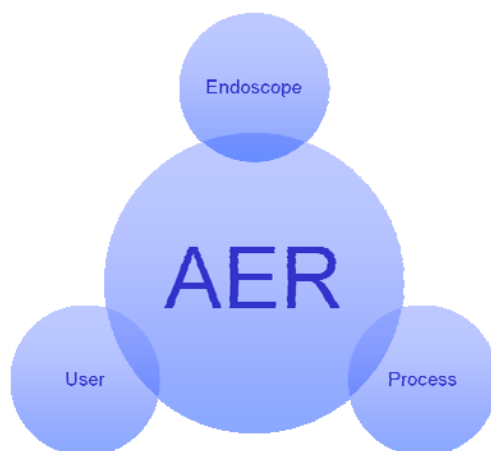
Simulated Use Full Cycle Testing



- **Endpoints**
 - **Protein:** < 6.4 µg/cm²
 - **Bioburden:** ≥ 6 Log₁₀ reduction in *M. terrae*
- **13 endoscopes, 65 samples**
Gastroscope, Colonoscope, Duodenoscope and Ultrasound Endoscope
- **Results**
 - **All samples < 6.4 µg/cm² residual protein**
 - **62 of 65 samples ≥ 6 Log₁₀ reduction in *M. terrae***
 - **3 samples > 5.9 Log₁₀ reduction – sample volume limitation**

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Summary



- Covers all Olympus endoscopes
- Reduced dependence on scope-specific adapters
- Reduced burden on user
- Simplified instructions
- ✓ Effective endoscope reprocessing

OLYMPUS



Workshop on Medical Device Cleanliness: How Clean is Clean Enough?

Sponsored by ASTM Committee F04 on Medical and Surgical Materials and Devices



Effects of Non-Aqueous Vapor Degreasing Solvent Cleaning on Ultra- High Molecular Weight Polyethylene (UHMWPE)

Ray Gsell, Ming Guo, Hallie Brinkerhuff
Zimmer, Inc., Warsaw IN, USA



Overview

- Provide a brief summary of the chemistry of HFES and HFCs
- Summarize the results of laboratory tests evaluating the interactions of HFES and HFCs with UHMWPE



Introduction

- Solvent degreasing operations have been historically used with great success
 - Mostly on metal and less so for polymeric components
- It had the advantages of:
 - Excellent cleaning power
 - Low surface tension solvents – small clearance cleaning
 - Low Boiling Point solvents – rapid drying
 - Simple equipment
- Historical degreaser solvents were ozone depleters
 - Fell out of popularity because of laws and costs of environmental controls
- New environmentally friendly solvents developed
- New solvent containment equipment designed



Introduction

- Composition of 3M HFE-72DA
 - Ethyl Nonafluorobutyl Ether
 - Ethyl Nanofluoroisobutyl Ether
 - Methyl Nonafluorobutyl Ether
 - Methyl Nanofluoroisobutyl Ether
 - IPA
 - *trans*-1,2-Dichloroethene



Introduction

- Composition of Micro Care Heavy Duty Degreasing Solvent
- 1,1,1,2,3,4,4,5,5,5-Decafluoropentane
- 1,1,1,3,3-Pentafluorobutane
- *trans*-1,2-Dichloroethene



Introduction

- Effects of Such Solvents on Metals vs. UHMWPE
 - Adsorption (unto) versus Absorption (into)
 - Absorption (into) versus Desorption (out of)



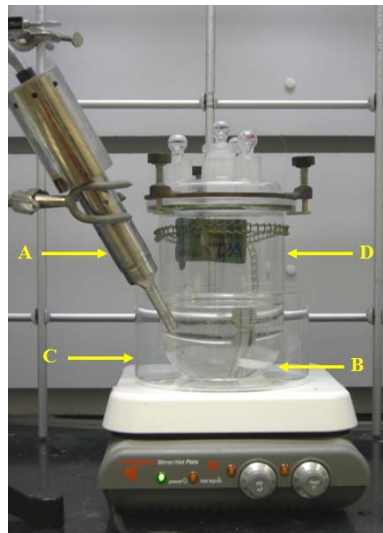
Test Methods

Material Processing Methods:

- Mimic Typical manufacturing processes Suggested by Solvent Suppliers
- UHMWPE Test Specimens:
 - 6 mm x 12 mm x 40 mm bars
 - GUR-1050 Compression Molded Slab Stock (Ticona)
- Typical Solvent Processing Cycle:
 - 1 minute soak in boiling solvent (HFE ~45 C, HFC ~41 C)
 - 2-5 minute agitated clean (with or without sonication)
 - 1 minute vapor phase rinse
 - 1 minute dry



Test Methods



- A – Sonication probe
- B – Sample submerged in solvent
- C – Beaker with water for sonication energy transfer
- D – Processing vessel



Test Methods

Material Post Cleaning Processing Methods:

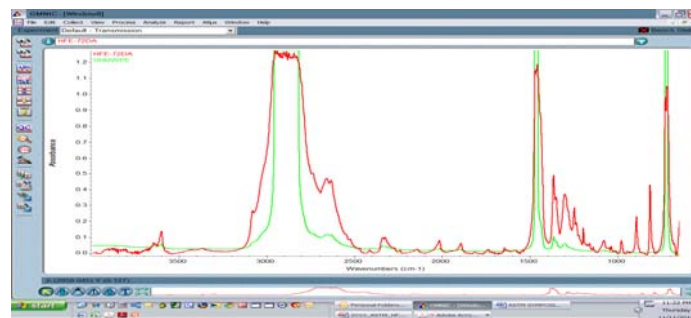
- Out-gassing, solvent desorption (drying):
 - Ambient air drying
 - 80 C oven drying
 - 80 C vacuum oven drying



Test Methods

Material Evaluation for Absorption/Desorption Characteristics:

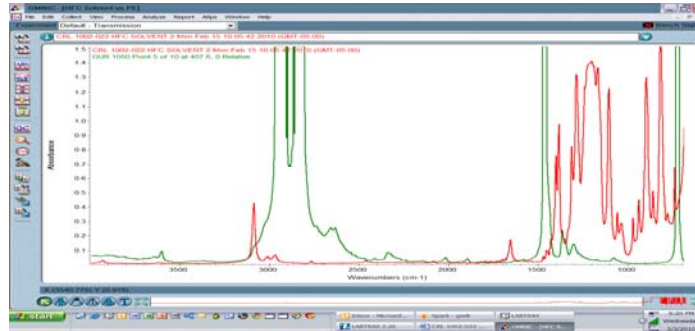
- Weight differences are not very accurate
- FTIR is very efficient at identifying the presence of these materials within the UHMWPE
- HFE/HFCs have unique FTIR absorption peaks from UHMWPE
 - HFE-72DA vs. UHMWPE



Test Methods

HFE/HFC Monitoring Methods:

- HDDS vs. UHMWPE



Test Methods

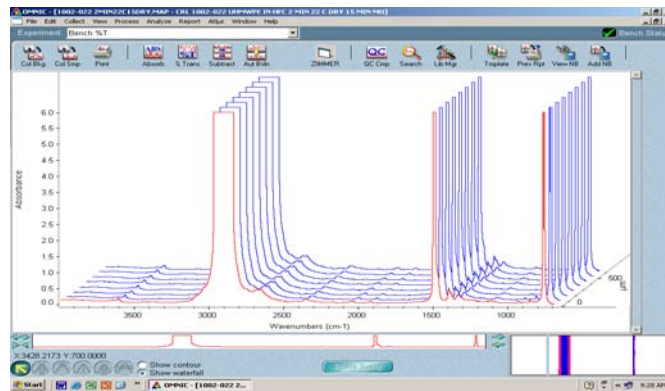
Material Evaluation for Absorption/Desorption Characteristics:

- FTIR Line-Mapping is very efficient at identifying the presence of these materials and their location within the UHMWPE
 - Processed UHMWPE bars are sectioned to obtain a fresh inner surface
 - ~150 Micron thick microtomed films are collected from this inner surface
 - FTIR transmission line-map spectra are collected every 200 microns starting from a solvent processed surface
 - Examination of individual line-map spectra allows one to determine the presence or absence of solvent and estimate its depth of absorption



Test Methods

- Typical FTIR Line-Map spectra



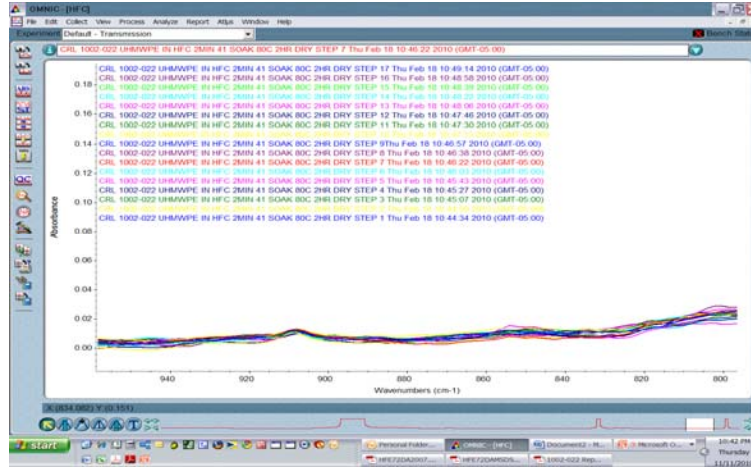
Results

- Typical depth profile of HDDS after 2-minute soak at 41 C



Results

- Typical depth profile of HDDS after a 2-minute soak at 41 C and 2-hour oven drying



Results Summary and comparison of HFE/HFCs

Samples of Tests and Results Using HFE-72DA and GUR 1050

Liquid Contact Time (Min.)	Vapor Contact Time (Min.)	Drying Time (Min.)	Drying Temperature (°C)	Drying Pressure (Atm.)	Solvent Absorbed (Y/N)	Maximum Depth (µm)
2	0	0	80/Oven	Ambient	Yes	250
2	0	15	80/Oven	Ambient	Yes	550
2	0	34	80/Oven	Ambient	Yes	750
2	0	50	80/Oven	Ambient	Yes	1100
2	0	90	80/Oven	Ambient	Yes	1300



Results Summary and comparison of HFE/HFCs

Samples of Tests and Results Using HDDS and GUR 1050

Liquid Contact Time (Min.)	Vapor Contact Time (Min.)	Drying Time (Min.)	Drying Temperature (°C)	Drying Pressure (Atm.)	Solvent Absorbed (Y/N)	Maximum Depth (µm)
2	0	0	Ambient	Ambient	Yes	200
2	0	40	Ambient	Ambient	Yes	500
2	0	68	Ambient	Ambient	Yes	600
2	0	0	Ambient	Ambient	Yes	300
2	0	30	80/Oven	Ambient	Yes	1000
2	0	60	80/Oven	Ambient	Yes	1100
2	0	90	80/Oven	Ambient	No	N/A
2	0	120	80/Oven	Ambient	No	N/A



Conclusions

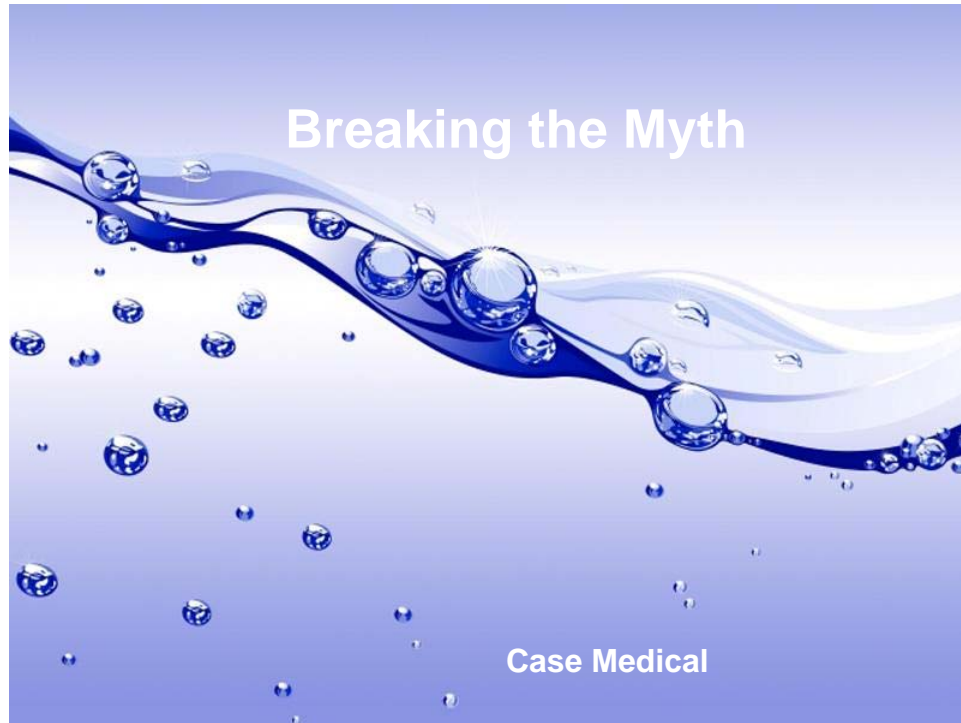
- These HFE and HFC solvents tend to be rapidly absorbed into UHMWPE during degreasing cleaning operations but only slowly desorbed
- The *trans*-1,2-Dichlorethene component is the 'culprit'
- HFC is desorbed more rapidly from UHMWPE than HFE
 - HFC was completely desorbed after 1.5 hours in an 80 C convection oven while HFE-72DA was still present
- Solvent components are absorbed to depths of ~1 mm with solvent contact times of about 2 minutes
 - Longer solvent contact times increases penetration depths
 - Sonication had little affect on penetration depths
- Elevated temperatures reduce desorption times
- Absorbed solvent moves deeper into material upon drying
- Vacuum oven had little affect on desorption times



Conclusions

- The use of HFEs and HFCs to clean UHMWPE is complicated by their rapid absorption but slow desorption from this material
 - Although the cleaning cycles may be significantly shorter than other methods the much longer desorption (drying) times may make the overall manufacturing process longer
 - Additional testing and documentation may be necessary to insure such a cleaning process produces a product that is free or 'essentially free' of residual processing materials





Our Position

- Caustic cleaners are unnecessary for instrument processing and present significant hazards to health and safety
- Properly formulated pH neutral instrument chemistries with excellent surfactants and synergistic enzymes can offer a safe and proven alternative
- The need to provide validated cleaning protocols for reusable medical devices has become a focal point in medical device reprocessing.



Sustainability

- Meeting the needs of our current generation without impacting the needs of future generations to meet their own needs
- Social responsibility to protect the public from exposure to harm
- All manufacturers are obligated to design instrument chemistries to control measures which may lead to possible harm.



Precautionary Principle

- Ethical responsibility to maintaining the integrity of natural systems
- Willingness to take action in advance of definitive scientific proof when a delay could prove costly to society and nature as well as selfish to future generations



Breaking the Chain

- Cleaning, decontamination and subsequent sterilization are essential steps in breaking the chain of infection.



Cleaning

- The removal, usually with detergent and water, of adherent visible soil such as blood, protein substances and other debris from the surfaces, crevices, serrations, joints and lumens of instruments, devices and equipment by a manual or mechanical process that prepares the items for safe handling and further decontamination.



Ineffective Cleaning

- Can affect the ability of medical devices
 - To function properly
 - Decreases the useful life of the device
 - Increases costs for repair and replacement
 - Can interfere with the effectiveness of subsequent sterilization or disinfection
 - Increases the risk of nosocomial infection



Green Chemistry

- Chemical products and processes designed to reduce or eliminate hazardous substances
- Pollution prevention focus of EPA's Green Chemistry program



Caustic Cleaners

- Alkaline detergents followed by acid neutralizers
- Present hazards to waste water stream
- Cause pitting and corrosion of surgical devices
- May result in safety issues for patients and staff



Warning

The use of elevated temperatures in a cleaning process will cause denaturation and precipitation of soil components (blood) and make them more difficult to remove.



Ideal Cleaning Agents

- Non-corrosive
- Free-rinsing
- Non-abrasive
- Low-foaming
- Biodegradable
- Environmentally Friendly
- Nontoxic in specified use dilution
- Provide for rapid soil dispersion or suspension
- May be used in all water types



Cleaning Reusable Devices

- The critical first step in the decontamination process
- Multi-step process including manual and automated cleaning
- Followed by a thorough rinse with high purity water
 - Manual cleaning dependent on individual's performance. Mechanical reproducible.



Validation

- The FDA places primary responsibility for developing and validating methods for effective processing of the medical device on the manufacturer of the device.
- Device manufacturers must provide procedures that must be easily replicated and verified by users



The Validation

- Enzymatic detergents are often recommended for cleaning reusable devices.
 - Yet, there was little data to confirm the efficacy of enzymatic detergents for effective soil removal from patient-used medical devices
- Validation: Simulated-use evaluation of enzymatic cleaning
 - Evaluated static soak, manual cleaning, automated cleaning, and the recommended process
 - Inoculated devices
 - Organic soil reduction
 - Bioburden reduction



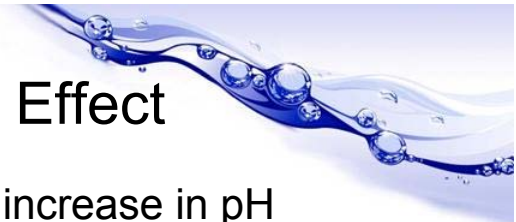
Validation of Process

- Pre-cleaning using a pH neutral multi-enzymatic foam
- Brief rinse with tap water
- Ultra sonic cleaning with pH neutral detergent
- Manual cleaning with pH neutral multi-enzymatic cleaner
- Final rinse with tap water



Results

- Hemostats soiled with ATS and microorganisms processed by the manufacturer's products and method resulted in a $\geq 6 \text{ Log}_{10}$ reduction bioburden and $> 99.9\%$ reduction in organic material post processing.
- Conclusion
 - The protocol of cleaning that is recommended by the manufacturer provides efficient cleaning of medical devices by providing soil and bioburden reduction.



The pH Effect

- To determine if an increase in pH (alkalinity level) will improve or change the outcome of the cleaning protocol
- Two parallel studies were conducted of the entire cleaning protocol
 - One using neutral pH detergent
 - One using the same ingredients but with a pH of 9 (alkaline)



pH Effect Results

- There was no significant difference in outcome between the pH neutral and the alkaline detergents
- In fact, there was a slight improvement in efficacy with the pH neutral detergent in replicate studies.



Why Use Enzymatic Cleaners?

- Each enzyme is a catalyst working on a particular substrate much as a lock and key. If one enzyme is used only one type of organic soil will be broken down.
 - Protease breaks down protein
 - Lipase breaks down lipids (fats).
 - Amylase breaks down starch and carbohydrates.
- Multiple enzymes are needed to attack organic soils, so that they may be washed away.
- Hot water is not recommended nor needed.



Why are Detergents Needed?

- Detergents are required for a thorough cleaning and removal of organic and inorganic soils, detergent residue, including enzymes.
- They may be used in hot water wash cycles for thermal disinfection.
- Detergents with chelating and sequestering agents are required for removal of salts, minerals and other hard water ions.
- In automated systems, when filtered, deionized or RO water systems are used lower concentrations of detergents may be used.



What Instrument Manufacturers Say

- Chemicals used in cleaning and decontamination processes should be able to remove the type of soil found on the item while, at the same time, preserving the integrity of the item. Such cleaning agents should have the following properties:
 - Ability to remove organic and inorganic soil.
 - Ability to prevent deposits from hard water ions.
 - Low foaming.
 - Free rinsing.
 - Neutral pH (range 7-8)
 - Very acid or alkaline solutions can damage the inert layer that keeps stainless steel instruments from corroding.
 - Anodized aluminum containers require pH neutral products for decontamination and to maintain their corrosion resistance and useful life.



Why Green Products?

- Environmentally friendly products are safe for the patient, staff, and the community.
- Color, dye, fragrance mask the degradation of the product (fading, sediment, mold!) and the odor of denatured enzymes.
- Most water systems in each of our cities limit the level of alkalinity in the water supply to a pH of 8.5, yet the alkaline detergents used may reach a pH of 14, the highest level possible and are dumped in our water supply, destroy medical devices, and if used on patients without rinsing, will cause injury or death.



Summary

- Medical devices are critical for patient care.
- No instrument company recommends caustic detergents, because of the potential damage to the device.
- Breaking the myth means that there are instrument chemistries that are pH neutral, validated in independent studies, that are environmentally friendly, safe and effective, and demonstrate efficacy and sustainability.



Workshop on Medical Device Cleanliness: How Clean is Clean Enough?

Sponsored by ASTM Committee F04 on Medical and Surgical Materials and Devices

Developing a method to quantitatively assess residual patient material in reusable medical devices

Shani Haugen, Ph.D.

Food and Drug Administration
Center for Devices and Radiological Health
Office of Science and Engineering Laboratories
Division of Biology

The comments and opinions
expressed in this presentation are
those of the speaker, and do not
necessarily reflect the formal position
of the FDA.

Outline

- Overview
 - Goals of project
- Background
 - Reprocessing reusable medical devices
 - Established methods of test soil detection
- Experimental approach
 - Preliminary data
- Future directions

Overview of Project

FDA has received reports of reusable medical devices that contain residual patient material even after being cleaned, which poses a risk for infection.

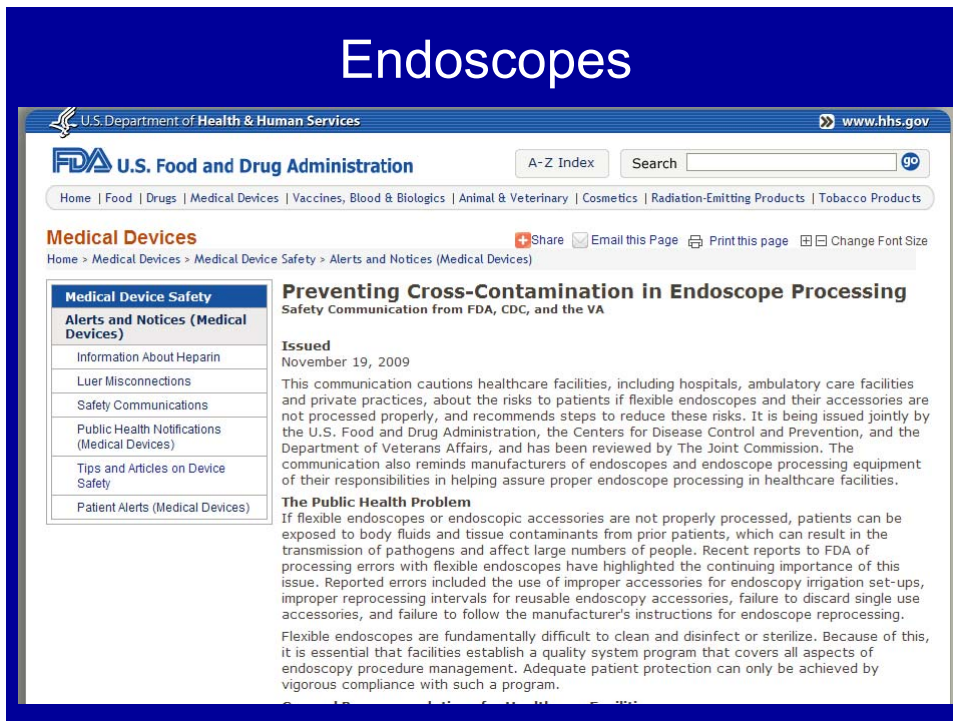
Goals:

1. To develop an assay for assessing residual debris in reusable medical devices
2. To quantitatively determine the impact of different device designs on the ability to remove organic material from reusable medical devices

Background

- Cleaning is an important first step in reprocessing for effective disinfection and/or sterilization of reusable devices.
- Organic material has been found to compromise the effectiveness of certain sterilization processes
- Improper cleaning of reusable devices (e.g. endoscopes) increases the possibility of infection for patients
 - Patient to patient transmission (Hepatitis)
 - Environmental transmission (*Pseudomonas*)

Endoscopes



The screenshot shows a web browser window displaying the FDA website. The page title is "Preventing Cross-Contamination in Endoscope Processing" and it is a safety communication from the FDA, CDC, and the VA, issued on November 19, 2009. The page content includes a "Public Health Problem" section stating that flexible endoscopes are difficult to clean and disinfect, and that improper reprocessing can lead to patient infections. It also mentions that the communication is intended to remind manufacturers of their responsibilities in ensuring proper endoscope processing in healthcare facilities.

Arthroscopic Shaver Handles

U.S. Department of Health & Human Services www.hhs.gov

FDA U.S. Food and Drug Administration A-Z Index Search

Home | Food | Drugs | Medical Devices | Vaccines, Blood & Biologics | Animal & Veterinary | Cosmetics | Radiation-Emitting Products | Tobacco Products

Medical Devices Share Email this Page Print this page Change Font Size

Home > Medical Devices > Medical Device Safety > Alerts and Notices (Medical Devices)

Medical Device Safety

Alerts and Notices (Medical Devices)

- Information About Heparin
- Luer Misconnections
- Safety Communications
- Public Health Notifications (Medical Devices)
- Tips and Articles on Device Safety
- Patient Alerts (Medical Devices)

Ongoing Safety Review of Arthroscopic Shavers

FDA has become aware of instances in which pieces of tissue have remained within certain arthroscopic shavers, a device used in some orthopedic surgical procedures, even after the cleaning process was believed to have been completed according to the manufacturer's instructions. Reports submitted to FDA suggested that the tissue retained was not evident to the naked eye. Multiple manufacturers of these devices recently informed their customers of this situation and reiterated the importance of proper cleaning procedures.

We are concerned about this because retained tissue in these devices can compromise the entire sterilization process. We are actively working with the manufacturers of these devices to gather more data about this situation and to understand its potential public health impact. As the FDA obtains more information that better defines the situation and determines whether there are specific risks, we will provide that information to facilities, health care providers and the public.

The FDA encourages facilities that use any of these types of devices to evaluate the adequacy of their cleaning procedures. Hospitals should consider taking the following steps to minimize any potential risk to patients:

- Be sure that all personnel responsible for device cleaning and sterilization at your facility are aware of and comply with all steps in the manufacturer's instructions for thoroughly cleaning these devices prior to sterilization. Please refer to the specific instructions provided in the labeling or user manual for each brand and/or model of shaver your facility uses.
- Consider inspecting the inside of the devices following cleaning to ensure that they have been cleared of any tissue or fluids. There may be multiple ways to accomplish this. As one example, the facility that brought this situation to our attention uses a 3mm video scope to inspect the channels of the shaver handpiece.

Background

April 2009

- During an investigation of an outbreak of Pseudomonas infections, a hospital found that some of their orthopedic surgical devices contained residual bits of patient material even after being cleaned
- residual organic material has been found to compromise the effectiveness of certain sterilization processes



Regulatory Relevance

- FDA has become aware of other types of reusable devices that retained patient debris after cleaning, indicating that this issue is not limited to a particular device or facility
- Manufacturers of reusable medical devices must provide users with reprocessing instructions, including cleaning instructions
 - cleaning instructions must be validated by the manufacturer as being effective to remove soil
 - manufacturers validate cleaning by performing simulated soiling and cleaning of the device, followed by some measurement of residual debris
- Any device that is found to have residual debris after performing the manufacturer-recommended cleaning steps should be reassessed to determine which aspect of the cleaning validation failed

Factors that must be considered for validation of cleaning

- type of test soil used (clinically relevant)
- location of the soil in device (inside device; under sheaths, etc.)
- method of inoculation of test soil
- length of time for the soil to dry on the device (to simulate worst case conditions)
- assessment of soil removal
- quantitative endpoints of “cleaned” device

Factors that must be considered for validation of cleaning

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- method of inoculation of test soil
- length of time for the soil to dry on the device (to simulate worst case conditions)
- assessment of soil removal
- quantitative endpoints of “cleaned” device

The ideal assessments for residue will be:

Accurate

Sensitive

Quantitative

Fast

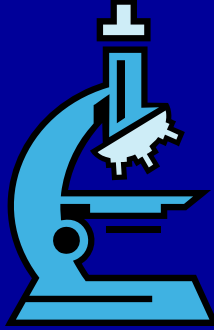
Easy

Inexpensive

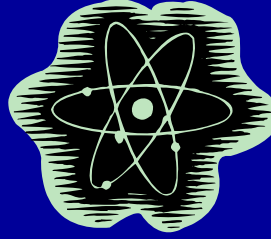
Can be used by manufacturers and users (using a test soil or clinical soil)

Methods that have been used to assay for residues

Direct



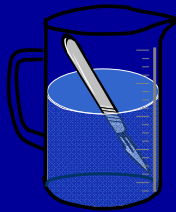
Scanning electron microscopy,
surface chemistry analysis,
photoelectron analysis
staining



Radionuclide tracers

Methods that have been used to assay for residues

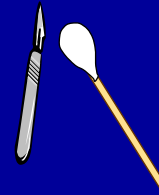
Indirect



Liquid Extraction



- Protein (Bradford, ninhydrin, autoanalyzer, etc.)
- Lipids and oils (Nile Red Dye)
- Carbohydrates (phenol-sulfuric acid protocol)
- Endotoxin (limulus amoebocyte lysate assay)
- Hemoglobin
- Total organic carbon
- Viable microorganisms

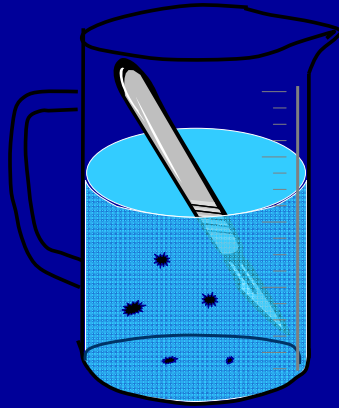


Swab



- Protein
- ATP fluorescence assay
- Viable microorganisms

The problems with solid debris in liquid eluate:



Sampling error

Inaccuracy

General Protocol

1. Apply test soil to device
2. Allow test soil to dry for defined time periods
3. Clean devices
4. Assess residual debris

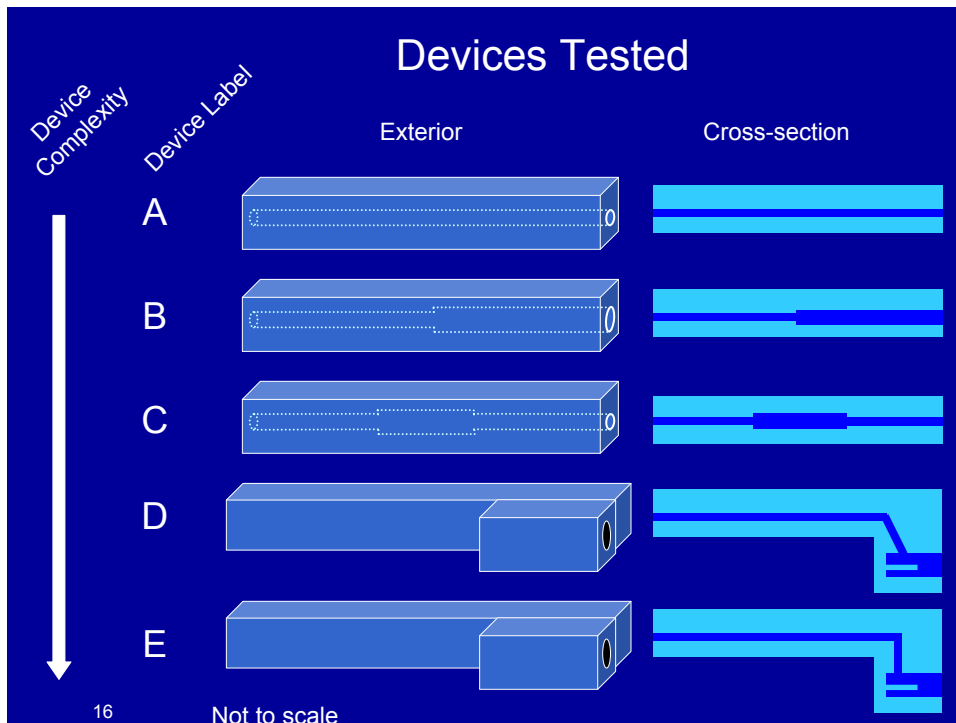
Test soil and inoculation

Test soil adapted from
Standardised Test Soil Blood 1: Composition, Preparation, Application
 M.Pfeifer, Zentr Steril 1998;6 (6);304-310

Coagulated blood test soil

- Purified blood proteins (hemoglobin, albumin, fibrinogen, thrombin)
- Forms a jello-like substance

- Dispense test soil directly into lumen of device
- Invert to mix, ensuring that all interior surfaces are coated with test soil
- Set down horizontally
- Allow to dry



General Protocol

1. Apply test soil to device
2. Allow test soil to dry for defined time periods
3. Clean devices
4. Assess residual debris

Assessments for debris

Swab – followed by Bradford assay for protein

Liquid extraction – followed by Bradford assay

HPLC analysis

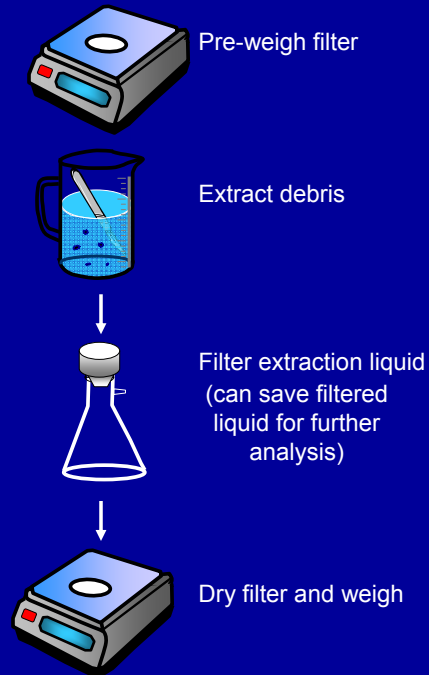
Mass spectrometry

Quantitative imaging analysis (FTIR/Raman spectroscopy)

Filter-weighing approach to assess residual debris in medical devices

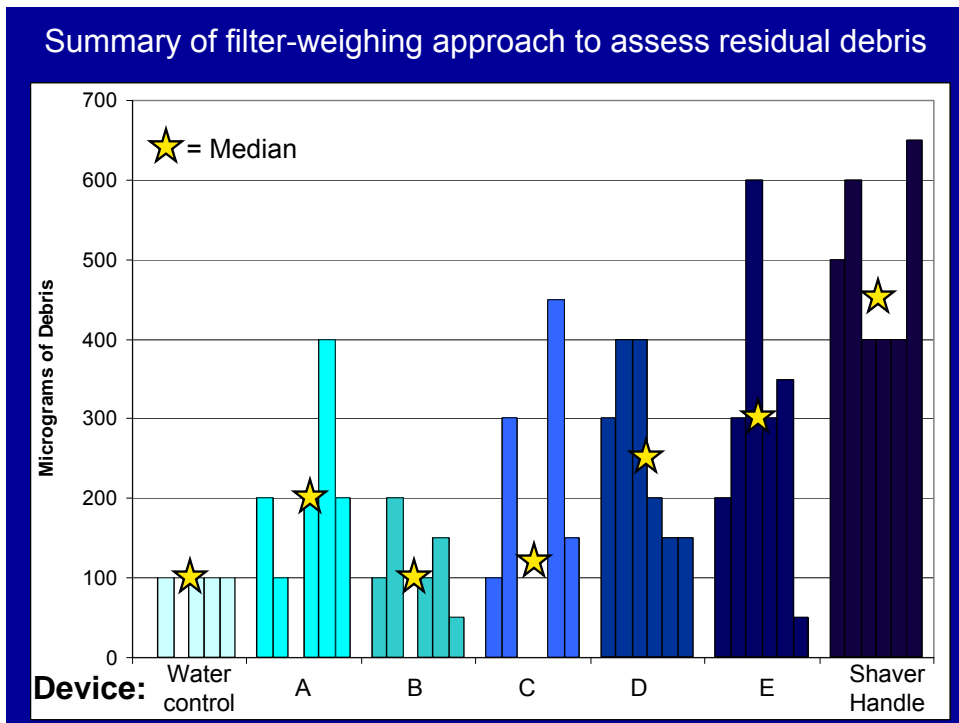
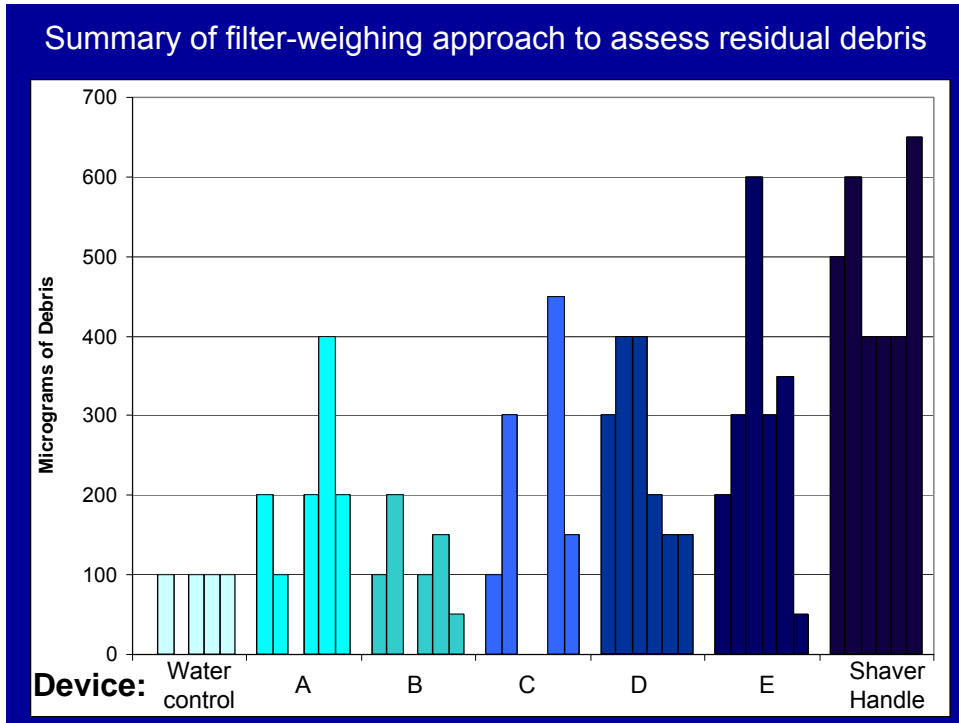
Equipment:

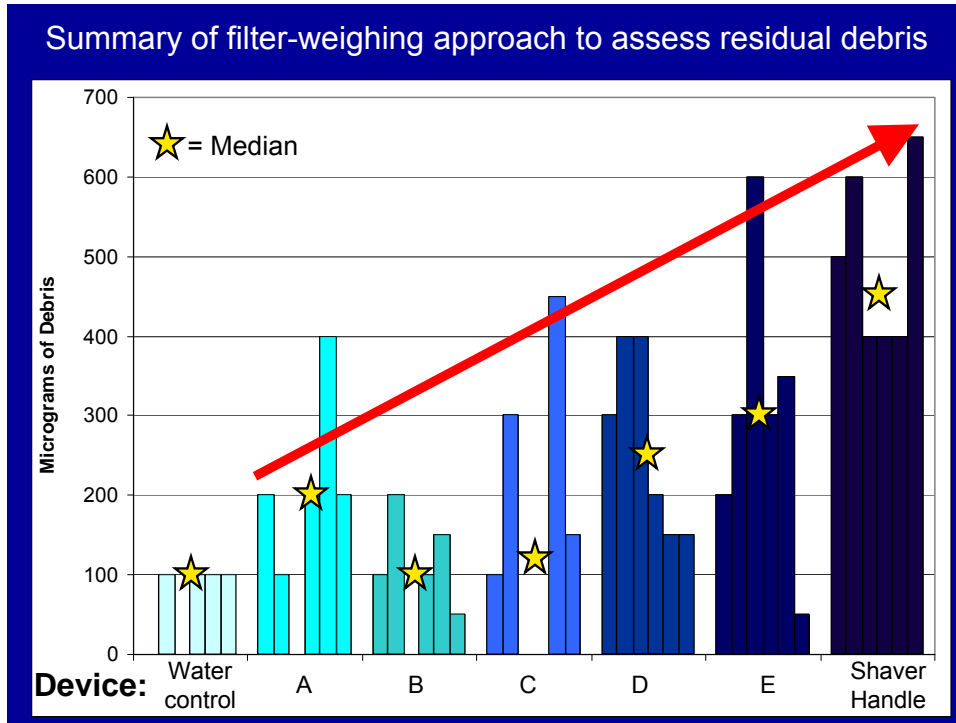
- Nylon filters (0.2 micron pore size)
- Microbalance (or analytical balance)
- Filtered water
- Container for device
- Filtering equipment



Filter-weighing method to assess residual debris

- Sensitive
- Quantitative
- Requires few pieces of specialized equipment
- Relatively straightforward to perform
- Saved filtrate can be used in downstream applications
- Entire sample is filtered – no sampling error
- Accurately quantifies insoluble material





Conclusions

The filter-weighing approach to assess residual debris in devices reveals a trend of increasing debris with increasing device complexity

These preliminary data support the continued development of the filter-weighing method to assess residual debris in reusable medical devices



Workshop on Medical Device Cleanliness: How Clean is Clean Enough?

Sponsored by ASTM Committee F04 on Medical and Surgical Materials and Devices

Future Experimental Directions

Repeat experiments with microbalance

Greater sensitivity – may more precisely define contributions from designs

Use imaging technology (with Division of Physics)

Characterize debris on filters using Fourier Transfer Infrared technology

Characterize debris inside devices using Raman spectroscopy with a microprobe

Purchasing additional medical devices

More data possibly relating debris retention to device design

Ability to see the range of debris found in these devices

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Sophia Tan
Ilko Ilev

FDA Commissioner's
Fellowship

Evaluation of the Cleaning Efficiency of an Aqueous Based Detergent System for Cleaning Metallic Medical Devices

16 November 2010

Boopathy Dhanapal, Nils Weiler and Jeff Rufner



Evaluation of the Cleaning Efficiency

- Introduction
- Scope
- Approach
- Results
- Conclusions

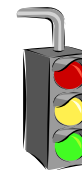


Introduction

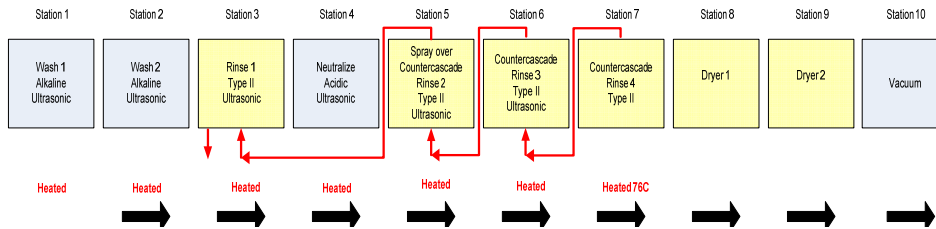
- To ensure consistent removal of manufacturing materials 21 CFR 820-70 and other contamination to predefined limits.
- ISO 13485, Section 6.4 / ISO TIR 14969, Section 6.4.2.2 requires that controls be established where the manufacturing environment could adversely impact product.



Evaluation of the dipping bath cascade



Robotic cleaning system



Test methods used

- Approach and Methods
- Potentiometric Titration three times a week
- pH and Temperature measurement
- Chemical Cleanliness Analysis of three different implants, three specimens per method: a total of 135 specimens analyzed



Fig. Titrimo & Autorepipet : tools used for the potentiometric titration



Stability of the detergent?

	Content Decrease/ %		
	Bath 1	Bath 2	Bath 4
Week 1	10.4	10.8	17.7
Week 2	2.3	2.3	12.4
Week 3	3.9	4.1	11.9



How do we ensure the detergent content?

- Systematic Deviation between potentiometric and visual Titration :

Calculated Top-up quantity*/ l	After 1 Week		After 2 Weeks	
	Pot Titration	Vis Titration	Pot Titration	Vis Titration
Bath 1	2.61	2.12	1.88	1.73
Bath 2	1.99	1.09	1.71	0.92
Bath 3	4.22	3.55	3.42	2.69

* Calculated from the Sodium Hydroxide/ Hydrochlorid Acid Usage and the multiplication factor from the technical sheet



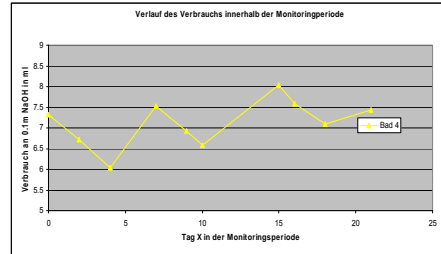
Cleanliness validation

Direct Analysis

Continuous Decrease of Detergent Concentration within a week.
Different Concentrations at the Beginning of the three weeks
After comparing the data: systematic deviation from the results of the visual Titrations

Product-related Analysis

With the actual life cycle, the required chemical cleanliness is generally assured.
No decrease of the chemical cleanliness was observed either within the week or three weeks.



Cleanliness validation

Part Description & Characteristics	Chemical Cleanliness Prior to the Cleaning Step		Chemical Cleanliness After the Cleaning Step	
	Average in mg/ Part	Max Value in mg/ Part	Average in mg/ Part	Max Value in mg/ Part
Hip Cup / Challenging Surface	Organic Residue: 5.9 TOC: 0.21 Ionic Residue: 1.24 Particulate Residue: 15.7	Organic Residue: 6.0 TOC: 0.22 Ionic Residue: 1.30 Particulate Residue: 23.6	Organic Residue: <0.5 TOC: 0.07 Ionic Residue: 0.07 Particulate Residue: 0.6	Organic Residue: <0.5 TOC: 0.08 Ionic Residue: 0.08 Particulate Residue: 0.8
Hip Stem / High Production Rate, Challenging Geometry	Organic Residue: <0.5 TOC: 0.09 Ionic Residue: 0.14 Particulate Residue: 2.9	Organic Residue: <0.5 TOC: 0.11 Ionic Residue: 0.19 Particulate Residue: 3.7	Organic Residue: <0.5 TOC: 0.05 Ionic Residue: <0.05 Particulate Residue: <0.2	Organic Residue: <0.5 TOC: 0.06 Ionic Residue: <0.05 Particulate Residue: <0.2
Femur Component / Highly porous surface	Organic Residue: 2.6 TOC: <0.05 Ionic Residue: 0.09 Particulate Residue: 0.4	Organic Residue: 2.9 TOC: <0.05 Ionic Residue: 0.09 Particulate Residue: 0.4	Organic Residue: <0.5 TOC: <0.05 Ionic Residue: <0.05 Particulate Residue: <0.2	Organic Residue: <0.5 TOC: <0.05 Ionic Residue: <0.05 Particulate Residue: <0.2

Table 1: Average Results: Total Organic Carbon (TOC), Organic Residual, Ionic Residual, Particulate Residual



Conclusions

1. Effect of the detergent concentration was studied by monitoring of the detergent baths. It was done via proven titration methods. Concentration of the detergent is important to ensure the cleanliness of the implants.
2. It is important to know the minimum and maximum concentration to meet the cleanliness requirements. This should be the starting point for the optimisation of a cleaning process.
3. Chemical residues on the implants are low after the cleaning process as expected.
4. An optimized cleaning process enhances consistency and predicatbility of the cleanliness of implants in accordance with CFR 211.611.



Thank you for your attention



Assessment of Organic Residues on Medical Devices

16 November 2010

Boopathy Dhanapal, Daniel Zurbürgg, Jeff Rufner
Ray Gsell.

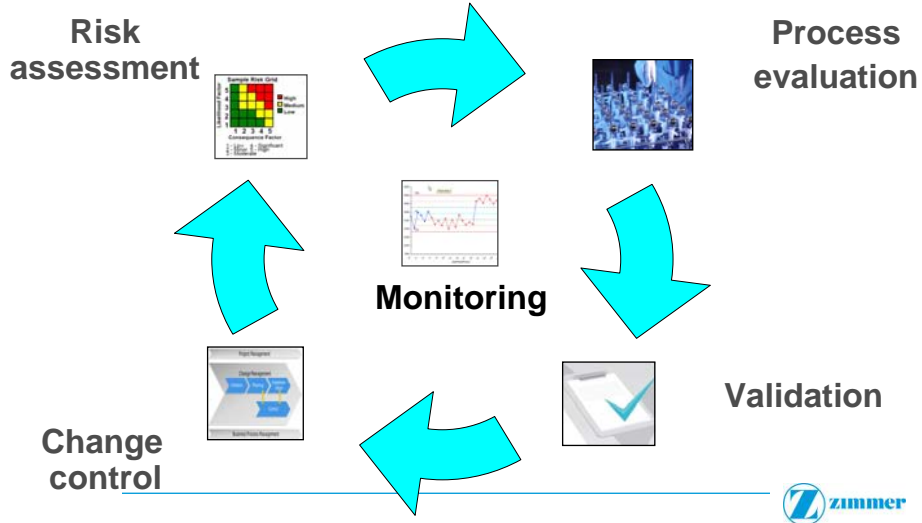


Introduction

1. Important steps for cleanliness assessment
2. Overview of test methods and evaluation
3. FTIR method for organic residues at low levels
4. Identification of residues by GC-MS



Cleanliness Assessment



Which Test Method ?

Only 1 test method (ASTM 2459) for non bio residues has been published

According to WK15532 more specific methods are required

No standard for non water-soluble organics (e.g. oil residues)



↓
Different strategies, methods and specifications to assess cleanliness
additional ASTM standards required



↓
Which test method is best?



Evaluation of Test Method

- Detectability of all potential residues
- Detection limit below specified cleanliness
- Compatibility of device with the method
- Quantitative (comparison with alarm / limit values)
- Accepted by authorities / standardized
- Costs and throughput time



Test Methods for cleanliness control I

	Technique	+	-
Direct Analysis (Surface)	Visual examination	<ul style="list-style-type: none"> • Rapid • Inexpensive • No extraction 	<ul style="list-style-type: none"> • Only large visible spots detectable • limited for complex surfaces
	SEM/EDX XPS TOF-SIMS	<ul style="list-style-type: none"> • Rapid identification • No extraction 	<ul style="list-style-type: none"> • no quant. of total MD surface • limited for complex surfaces
Indirect Specific Analysis (Extraction)	GC-MS ICP-MS	<ul style="list-style-type: none"> • Identification of mixtures • Low LOD: ng/device 	<ul style="list-style-type: none"> • Not universal • Expensive • Complex

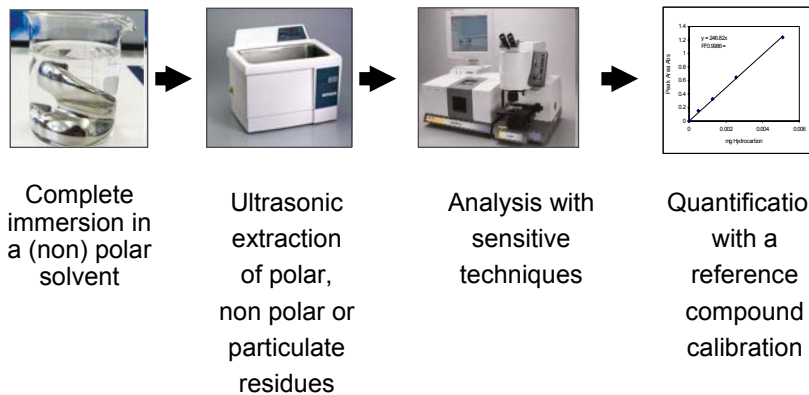


Test Methods for cleanliness control II

	Technique	+	-
Indirect Universal Analysis (Extraction)	TOC USP 643	<ul style="list-style-type: none"> low LOD: 0.03 mg all water-soluble organics 	<ul style="list-style-type: none"> no nonpolar organics recovery valid.
	FTIR ASTM JAI13391	<ul style="list-style-type: none"> low LOD: 0.03 mg nonpolar organics 	<ul style="list-style-type: none"> polymer leachables recovery valid.
	Conductivity USP 645	<ul style="list-style-type: none"> inorganic and organic ions inexpensive 	<ul style="list-style-type: none"> limited to ions recovery valid.
	Gravimetry e.g. ASTM F2459	<ul style="list-style-type: none"> most universal: all nonvolatiles Inexpensive 	<ul style="list-style-type: none"> high LOD: 0.3 mg/device recovery valid.
	Particle count USP 788	<ul style="list-style-type: none"> low LOD: a few particles 	<ul style="list-style-type: none"> no solubles recovery valid.

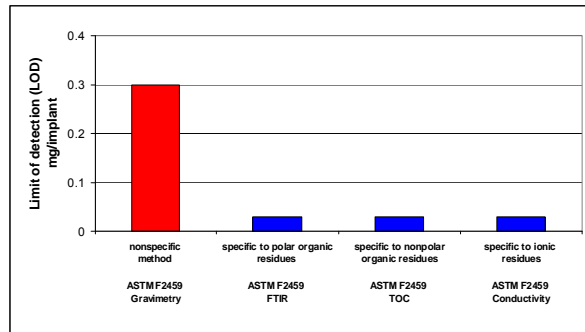


Principle of Cleanliness Testing with Extraction



Limitation of ASTM F2459 / Gravimetry

- LOD of 0.3 mg not low enough for cleanliness assessment
- Differentiation between (inorganic / organic) not possible
- long-term experience for reproducible analysis required
- More sensitive methods (e.g. FTIR) 10 x lower LOD required



FTIR Method for Organic Residues



Extraction acc. ASTM F2459 with carbon tetrachloride (CCl₄)

polymers:	1-10 min Ultrasonic (US) at room temperature (RT)
metals:	US / RT structure dependent
ceramics:	US / RT
Hydroxyapatite	US / RT

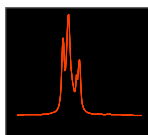


Measurement of IR spectra by FTIR based on ASTM F1374-92¹

direct measurement of extract in transmission (1 cm cuvette)
recording spectra in the range from 2500 – 4000 cm⁻¹
covers all extractable hydrocarbons (oil, cooling agents etc.)

Quantification

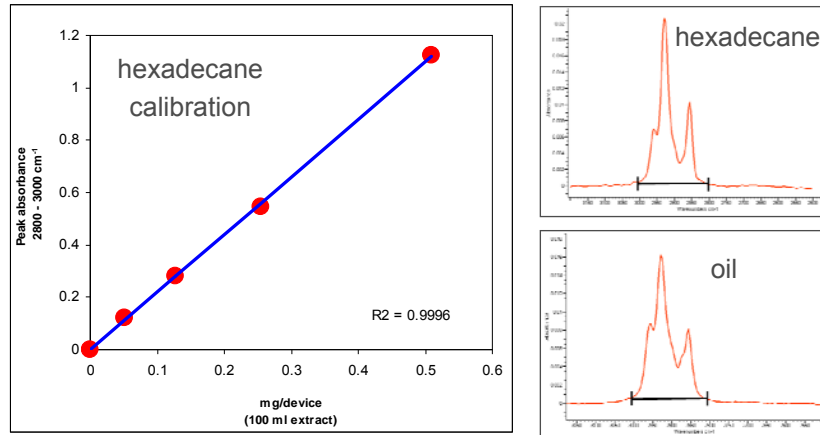
integration of hydrocarbon peak (C-H) in the range from 2800 – 3000 cm⁻¹
quantification against a reference hydrocarbon (hexadecane or reference oil)
results in mg/implant or mg/area



¹⁾ ASTM F1374-92 Standard Test Method for Ionic/Organic Extractables of Internal Surfaces-IC/GC/FTIR for Gas Distribution System Components (Ultra-High-Purity Gas Distribution Systems)

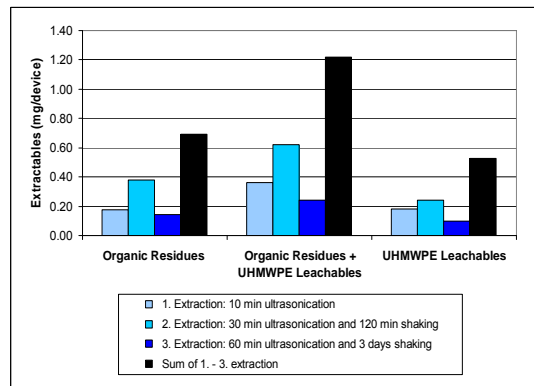


Quantification by FTIR

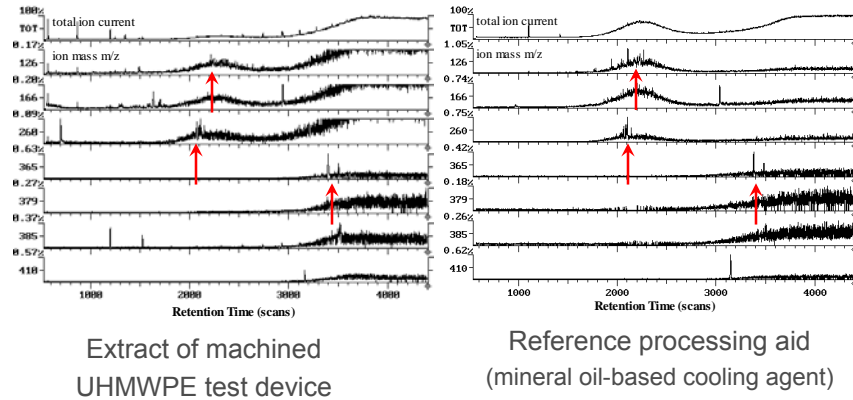


Organic Residues / Polymer Leachables

Extraction of polymers can release polymer leachables
Differentiation residues / leachables if possible



Identification of Residues by GC-MS



Conclusions

- ASTM F2459 can be used for polymeric implants
- Gravimetry alone may not be sensitive enough for cleanliness assessment, therefore it should be used in combination with other analytical techniques.
- Extraction ASTM F2459 with FTIR
 - Sensitive enough with LOD of 0.03 mg/implant
 - Good recovery also at low levels > 80 %
 - Specific to extractable hydrocarbons, such as oils
- Publication of ASTM standards with FTIR specific for MD
- Highly specific methods (GC-MS) only for identification required



Thank you for your attention





Workshop on Medical Device Cleanliness: How Clean is Clean Enough?

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Consulting, LLC

Quality Validations, Experience, & Training

Establishing and Justifying Limit Values for Residual Analysis

Kierstan Andrascik

ASTM Workshop on Medical Device Cleanliness:
How Clean is Clean Enough?

Between a Rock and a Hard Place



Regulatory Limits?

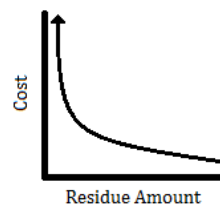
- ▶ Contaminant Toxicity
- ▶ Quantity Used
- ▶ Patient Exposure

- ▶ It's up to YOU!



Establishing Limit Values

- ▶ Zero?
- ▶ I don't think so...



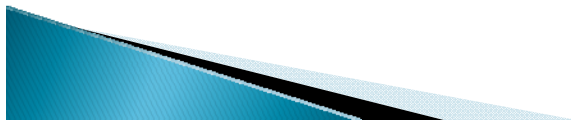
- ▶ Validate your cleaning process
 - Choose test method
 - High and low parameters
 - Nominal parameters

Expressing Residue Amounts

- ▶ mg/cm^2 or $\mu\text{g}/\text{cm}^2$
- ▶ mg/device or $\mu\text{g}/\text{device}$

- ▶ Limit values in same units

Surface Area



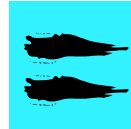
Statistical Comparison

- ▶ Average and Standard Deviation
- ▶ T-test
- ▶ ANOVA
- ▶ Confidence Intervals
- ▶ Uncertainty of Test Method



Baseline Comparison

- ▶ Test “Off the Shelf” Devices
- ▶ Compare to Freshly Cleaned Devices



Biocompatibility

- ▶ Biocompatible Clean Device

=

- ▶ Biocompatible Residues

- ▶ Cytotoxicity
 - Sensitive In-Vitro Method
 - Pass/Fail Criteria



Other Testing

- ▶ Endotoxin
 - Not removed by sterilization
 - Better to prevent or limit contamination
 - Pass/Fail Criteria

- ▶ Bioburden
 - Primarily removed by sterilization
 - Can be removed during cleaning process
 - 3 log reduction



Risk-Based Assessment

- ▶ Patient Exposure
 - How long
 - Where

- ▶ Percent or Log Reduction
 - LD50
 - TDLO

MATERIAL SAFETY DATA	
SECTION 4 - FIRST AID	
irritation:	Flush with large amounts of water for at least 15 minutes. Do not
skin:	Wash affected area gently with soap and water. Skin cream or ointment
eyes:	Do not induce vomiting; drink plenty of water.
ingestion:	Remove affected person to clean fresh air.
SECTION 5 - FIRE FIGHTING MEASURES	
Flammability:	Non-combustible
Extinguishing media:	Use extinguishing media appropriate to the surrounding fire.
Hazards:	None
Special precautions for fire-fighting:	Wear full bunker gear including positive pressure self-contained breathing apparatus.
SECTION 6 - ACCIDENTAL RELEASE MEASURES	
Prevention:	Avoid creating airborne dust. Follow routine housekeeping procedures. Use filtered equipment. If sweeping is necessary, use a dust suppressant. Do not use compressed air for clean-up. Personnel should wear approved respirator. Avoid clean-up procedures that could result in dust release.
SECTION 7 - HANDLING AND STORAGE	
Handling:	Limit use of power tools unless in conjunction with local exhaust ventilation. Frequently clean the work area with HEPA filtered vacuum or HEPA filtered air. Do not use compressed air for clean-up.
Storage:	This product is stable under all conditions of storage. Store in a cool, dry place.



Recommendations

- ▶ Clear and concise
- ▶ Re-evaluate as needed
- ▶ Justifiable with wiggle room



Quality Validations, Experience, & Training

Questions?

Email: kandrascik@comcast.net



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ASTM Workshop on Medical Device Cleanliness

**Steve Goldstine Consultants
SteveGoldstine@Yahoo.com**

11/16/2010

ASTM: Cleanliness of Medical Devices

ASTM Workshop on Medical Device Cleanliness

Standard Practices & Guides for Processing Reusable Medical Devices

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ASTM: Cleanliness of Medical Devices



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Can we develop a standard guide or practice for cleaning and processing reusable devices for subsequent uses, particularly cannulated medical devices?

Standard Practice for Cleaning and Disinfection of Flexible Fiberoptic and Video Endoscopes Used in the Examination of the Hollow Viscera (ASTM F 1518-00)

Standard Practice for Reprocessing of Reusable, Heat-Stable Endoscopic Accessory Instruments (EAI) Used with Flexible Endoscopes (Reapproved 2007) (ASTM F 1992-99)

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Can we develop a standard guide or practice for cleaning and processing reusable devices for subsequent uses, particularly cannulated medical devices?

Standard Practice for Care and Handling of Orthopedic Implants and Instruments (ASTM F565 – 04- 2009)

Standard Guide for Care and Handling of Stainless Steel Surgical Instruments (ASTM F1744 – 96- 2008)

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Can we develop a standard guide or practice for cleaning and processing reusable devices for subsequent uses, particularly cannulated medical devices?

Existing Guides & Practices:

- **Update & Revise**
- **Add Discussion or Recommendations for Verification of Cleaning (non-visual)**

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ASTM Workshop on Medical Device Cleanliness

Residual soil on reusable medical devices: A challenge to the standards community

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Cleaning of Reusable Medical Devices

- **Disease Transmission**
- **Occupational Exposure to Potentially Infectious Materials**
- **Interference with Subsequent Disinfection or Sterilization**
- **Device Performance**

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Visibly Clean & Device Design

- **Serrated edges**
- **Hinges**
- **Acute angles**
- **Coils**
- **Junctions between insulating sheaths**
- **Long or narrow opaque lumens**

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Recent History

**Designing, Testing, and Labeling Reusable
Medical Devices for Reprocessing in Health
Care Facilities: A guide for device
manufacturers (AAMI TIR12—1994)**

**Labeling Reusable Medical Devices for
Reprocessing in Health Care Facilities: FDA
Reviewer Guidance (FDA-1996)**

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Standard Test Methods

**Standard Test Method for Determination
of Effectiveness of Cleaning Processes for
Reusable Medical Instruments Using a
Microbiologic Method (Simulated Use
Test) (ASTM E2314 – 03 - 2008)**

**Tests the efficacy of a cleaning process for
reusable medical instruments artificially
contaminated with mixtures of
microorganisms and simulated soil.**

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Standard Test Methods

Standard Guide for Blood Cleaning Efficiency of Detergents and Washer-Disinfectors (ASTM D7225 - 06)

Standard test soil correlating to coagulated blood suitable for screening tests and the evaluation of the cleaning efficiency of washer-disinfectors used for reprocessing of surgical instruments.

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Cleaning Review

A compendium of processes, materials, test methods, and acceptance criteria for cleaning reusable medical devices (AAMI TIR30:2003)

Compilation of available information that can be used by medical device manufacturers to validate cleaning processes for reusable medical devices.

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A Cleaning Review

A compendium of processes, materials, test methods, and acceptance criteria for cleaning reusable medical devices (AAMI TIR30:2003)

- Device design & materials
- Available cleaning processes
- Test soils
- Test methods, equipment, and acceptance criteria
- Regulatory considerations

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Standard Test Methods

Washer-disinfectors -- Part 1: General requirements, terms and definitions and tests (ISO 15883-1:2006)

Defines general performance requirements for washer-disinfectors and that are intended to be used for cleaning and disinfection of re-usable medical devices.

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Standard Test Methods

Part 1: General requirements, terms and definitions and tests (ISO 15883-1:2006)

Part 2: Requirements and tests for washer-disinfectors employing thermal disinfection for surgical instruments, anaesthetic equipment, bowls, dishes, receivers, utensils, glassware, etc. (ISO 15883-2:2006)

Part 3: Requirements and tests for washer-disinfectors employing thermal disinfection for human waste containers (ISO 15883-3:2006)

Part 4: Requirements and tests for washer-disinfectors employing chemical disinfection for thermolabile endoscopes (ISO 15883-4:2008)

Part 5: Test soils and methods for demonstrating cleaning efficacy (ISO/TS 15883-5:2005)

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Standard Test Methods

Part 5: Test soils and methods for demonstrating cleaning efficacy (ISO/TS 15883-5:2005)

“The current state of knowledge has not permitted development of a single internationally acceptable test method”

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Standard Test Methods

Part 5: Test soils and methods for demonstrating cleaning efficacy (ISO/TS 15883-5:2005)

- The 19 test soils and methods from national standards and published documents

Blood

Wallpaper Paste

Instant Potato Flakes

Eggs / Egg Yolks

- Acceptance criteria are based on visual inspection (n=18) and/or a microbiological end-point (n=6).

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Moving Forward

Part 5: Test soils and methods for demonstrating cleaning efficacy (ISO/TS 15883-5:2005)

Revision of Part 5:

1. Artificial Soil (organic)
2. Quantitative Endpoint
3. Standard Instrument Test Loads
4. [Need for relevant verification tests]

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