Organic Contamination Control

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Viking Approach

"The basic requirement that had to be satisfied was that the soil samples delivered to the GCMS experiment were each to contain less than one part per million organic material of terrestrial origin per the mission definition document" (ref. Viking report)

"...analyses indicated that:

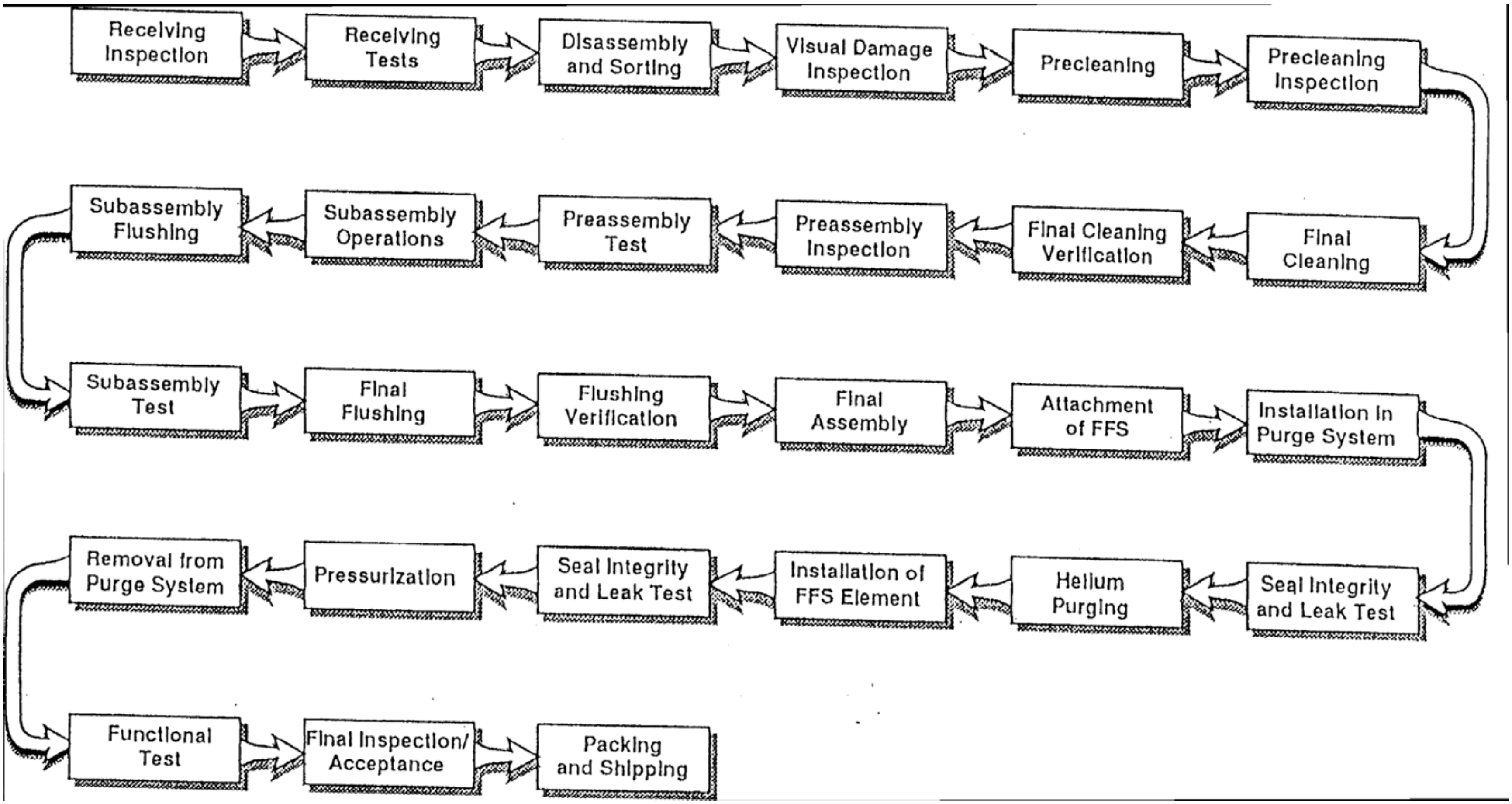
1. the sample path hardware would have to be cleaned to one nanogram per square centimeter,
2. the sample path hardware would have to be sealed and pressurized after clearing to protect against recontamination,
3. the use of organic materials in the sample path hardware would have to be controlled and minimized,
4. the use of hermetically sealed devices would have to be implemented where possible, and
5. the sample path hardware would have to experience a hot helium purge prior to sealing and pressurization" (ref. Viking report)

"In order to verify the approach taken and to better understand the possible impact on equipment design, several elements of prototype hardware and development hardware were processed through WSTF" (Viking report)

Viking Cleaning

“The following sequence of cleaning activities was verified as being acceptable to satisfy the overall organic contamination requirement. Upon receipt of the flight equipment at WSTF, it was disassembled and inspected for cleaning. The parts were then cleaned to the nanograde level by precleaning with detergents, isopropyl alcohol, trichlorethylene, or benzene/methanol. Final cleaning was accomplished by sonic cleaning in triple distilled freon TF in a 100-class clean room. Reassembly, inspections, and flushing of the sample path- hardware was accomplished in the 100-class clean room. To verify the cleaning process particle count and the total hydrocarbon count, detail purges and flushes were conducted. The millipore methods were utilized for particle count and a final flush effluent was injected into the gas chromatograph (GC). A hot-helium purge was then used to remove residual solvent and the effluent was analyzed by the GC to verify cleanliness level. The typical flow for flight hardware processing is shown in Figure 2.9. Also, data from the Viking flight spare LPA is provided in Figures 2.1 OA-2.lOD as examples of the data obtained during the hot-helium purge process”(Viking report)

Viking Cleaning



MEPAG OCSSG

A current goal of the MEP is to achieve an understanding of the possible emergence and duration of life on that planet

The Mars Program Office chartered the Organic Contamination Science Steering Group (OCSSG) to define the contamination problem and suggest plans and priorities for solutions

The primary focus of the study was organic contamination introduced into those samples that would be delivered to sensitive analytical instruments after processing by lander acquisition and sampling devices (derive requirements for MSL)

Table 2. Maximum amount of contamination in nanograms (ng) that can be transferred to organic and molecular analysis experiments prior to their delivery to the instruments.

	ng / g sample	Notes
Benzene or aromatic hydrocarbons	8	MSL will delivery approximately 5 g of sample to the processing system. Individual experiments may require only a few milligrams of sample for their analysis
Carbonyl and hydroxyl containing compounds	10	
Amino acids	1	
Amines, or amides	2	
Non-aromatic hydrocarbons	8	
DNA	1	
Total reduced carbon	40	

Assumptions: State of organic cleanliness can be assessed by analyzing specific representative molecules.

ExoMars Contamination Control

Input from instrument team for acceptable terrestrial organic contamination per gram of sample delivered to the instrument: 50 ng range for organics of biological sources but allows up to µg for tested engineering sources

Applicability of requirements on “subsystems involved in the acquisition, delivery, and analysis of martian samples for life detection”

Contamination control tiger team established in 2008 to respond to the very demanding planetary protection and organic contamination control requirements for the ExoMars mission

The tiger team was chaired by the planetary protection lead of the prime contractor, membership included ESA and prime contractor project personnel, representatives from affected sub-contractors (“sample acquisition and delivery”) and instrument teams (“sample analysis”)

Major output:

- → Identification of critical materials based on requested Declared Material List (DML) of sub-contractors and instrument providers
- → Selection of materials for testing and test specification
- → Identification of modeling approach for contamination transport analysis
- → Identification of precision cleaning approach

ExoMars Contamination Control

Material control based on elimination, conditioning, isolation or characterization

Organic inventory is not limited to sample of hardware present on the flight system in excess of 25 kg

Design to protect the sensitive surfaces based on segregation (sealed sample path) and overpressure

Aseptic, ISO 3, ISO AMC-9 cleaning and assembly environment for sample path

Cleaning approach:

- → Start cleaning at the lowest level, i.e. parts level
- → Start bakeouts at the lowest integration level, i.e. sub-assemblies
- → Perform sterilisation at the highest integration level possible

Cleaning based on sequence of solvent cleaning (sonication), bake out, CO_2 snow cleaning, hot gas purge

Pre-launch verification of primary requirement (terrestrial contamination of the sample) with end-to-end test (“subsystems involved in the acquisition, delivery, and analysis of martian samples”) with qualification model approach

- → **Cannot verify everything on flight model → impact on model philosophy**
- → **Interfaces are critical**

Conclusions

“In conclusion, the Viking experience, with extremely sensitive instruments capable of performing in situ biological and molecular-analysis (organic chemistry) investigations of martian surface material, is felt to be directly applicable to MRSR missions” (ref. Viking report)

“Each discipline should be evaluated early in the development of the program mission plan, and the specific requirements should be defined at that time so that they can be implemented into contract statements of work. It is probable that these requirements will, in turn, necessitate early technology developments to satisfy specific hardware requirements in accordance with PP policy” (ref. Viking report)

In summary, stringent contamination control requirements have an impact on the flight system design, on the use of materials and components (heritage!!!), model philosophy, qualification and verification approach – **this is more difficult than just bioburden control**

JSWG recommendation: technology development in the areas of planetary protection, contamination control, and sample integrity technologies to achieve the stringent requirements on the levels of terrestrial contaminants in collected samples, both for in situ analysis and for the cached samples

Recommended Reading

Lessons learned from the Viking Planetary Quarantine and Contamination Control Experience, The Bionetics Corporation, NASA Contract NASW-4355

Science Priorities Related to the Organic Contamination of Martian Landers, MEPAG white paper, 2004

Report of the 2018 Joint Mars Rover Mission Joint Science Working Group (JWSG), 2012