



M+W GROUP



Laboratory Services for Controlled Environments

M+W Products – Laboratory Services



Semiconductor Fab Globalfoundries, Dresden, Germany



Sample preparation

M+W Group at a Glance

M+W Group is the leading global engineering, construction and project management company in the fields of Advanced Technology Facilities, Life Science & Chemicals, Energy & Environment Technologies and High-Tech Infrastructure. In 2012, with more than 7,500 employees and an order intake of over \$ 3.6 billion M+W Group celebrated its 100th anniversary.

M+W Products

M+W Products is one of the world's global leading companies for cleanroom technology systems with extensive experiences in high-precision climate-control systems and contamination control in all industries with ultraclean production requirements. We offer substantial experience in the semiconductor, photovoltaic, flat-panel, life science, automotive, IT, and food industries. M+W Products assists customers in every process phase: from consulting, engineering, manufacturing and commissioning to after sales services. As a member of the M+W Group, our worldwide sales and service network is a great advantage to our customers and enables us to support them in every stage of their critical production processes.

Laboratory Services

Our chemical-analytical laboratory has in-depth knowledge in the field of air and water analyses for clean environments. Many years of experience with chemical contamination analysis make our laboratory a competent partner in terms of cleanliness investigations. State-of-the-art analytical equipment combined with approved and validated analytical procedures ensure reproducible and reliable analytical results.

A high quality control of processes and outcomes is guaranteed to our customers due to our ISO 9001 certification. Moreover, our complete quality management system ensures maximum transparency. In this regard, our customers appreciate our reliable analyses as well as our excellent services.

Key Facts

- Total laboratory space: 470 m²
- Team: Chemists, laboratory assistants and technicians
- Available cleanroom space up to ISO class 3
- Ultra-trace analysis in ppb to sub-ppt range
- Particle detection in air and liquids

Qualification

Concept

Installation

Verification

Contamination Control



Cleanroom at M+W for ultra-trace analysis



Filter test setup

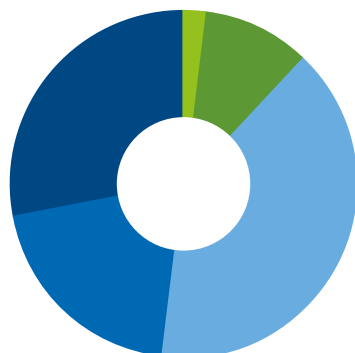
Analysis and Services

Many industries require clean environmental conditions for optimal product quality, stability of production processes and production yield.

As a consequence, cleanroom air, gas supply as well as all materials, components and tools used in a cleanroom environment have to fulfill specified cleanliness levels. In addition stable process conditions require consistently high quality process media (e.g. XCDA, nitrogen, ultrapure water). In order to identify all sorts of contaminations and its sources, our laboratory provides a complete service of air, water and process media analysis as well as material investigations according to verified and standardized methods.

Our services cover the development of customized and application oriented methods and procedures, efficient solutions concerning quality assurance issues as well as routine analyses. Evaluation of cleanliness, cleanroom environments validation and monitoring as well as certification of contamination-critical products and components is our core business. In this context testing and qualification of chemical filter materials play a major role in controlling all kind of contaminations in clean environments.

The laboratory is well connected to local experts and engineers as well as to the network of the worldwide M+W Group. Our state-of-the-art test and measurement equipment enables us to work on the latest requirements in airflow management, particle control and airborne molecular contamination (AMC) issues. Our analytical techniques are especially optimized for trace analysis down to sub-ppt range.



- Cleanroom technology
- Staff
- Manufacturing equipment and materials
- Manufacturing processes
- Others (e.g. logistics)

Influence factors upon the product cleanliness for semiconductor manufacturing. Source: IPA Fraunhofer.

Air Quality Monitoring



450 mm pilot line at G450C FAB, SUNY CNSE facility, Albany, NY



Filter Fan Units with AMC-filter (V-shape)

Contamination Detection

Complex and special manufacturing processes in electronic and semiconductor industries require high cleanliness of ambient air. Chemical gas-phase contaminations, so-called airborne molecular contaminants (AMC), can form thin chemical films on critical surfaces. Stringent monitoring of indoor air quality enables to comply with high technology production environments.

Air Control for Environment, Health and Safety

One objective in protecting the health and safety of employees is to reduce indoor pollution by identification and elimination of harmful, carcinogenic and toxic substances. In order to evaluate the air quality within a building or at any location all kinds of harmful substances must be identified and potential outgassing materials like cleaning products, construction materials, paintings or consumer goods should be analyzed according to their volatility.

Services in the Field of Air Analysis

M+W Products provides expertise in measuring, identifying and controlling air contamination. This enables our customers to improve their manufacturing processes as well as their product yields.

In order to detect all kinds of air contamination our M+W Products laboratory offers a complete air and ambient analysis service:

- Monitoring of air inside and outside of cleanroom installations
- Air sampling inside and outside of mini environments and working environments
- Determination of pollutants in indoor air environments (work spaces, offices, factory buildings)
- Evaluation of material outgassing
- Ultra trace analysis in ppb to sub-ppt range
- Analysis on typical AMC substances:
 - Total volatile organic compounds (VOC) and semivolatile organic compounds (SVOC), including organic amines and refractory compounds as well as specific organic compounds like PGMEA, ethyl lactate by TD-GC/MS
 - Ions: organic and inorganic acid anions, ammonium and other cations by ion chromatography (IC)
 - Trace metals, dopants included (B, P, Sb, As) by ICP-MS

AMC

Acids
Bases
Condesables
Dopands

- Contaminating critical surfaces like wafers, reticles, masks and inspection tools
- Corrosion on wafer surface
- Uncontrolled boron and phosphorous doping
- Wafer and optics haze
- T-Topping
- Particle generation



Contamination sources from outside of the fab



Cleanroom – ready for equipment

Monitoring the Air Quality outside of the Fab

For planning and designing appropriate air treatment facilities, especially for cleanrooms, the knowledge of the outdoor air quality at a certain location is mandatory.

M+W Products laboratory offers:

- Evaluation of environmental conditions by measurement of outdoor air in order to choose the optimal location and adequate air treatments for new fabs and cleanroom installations
- Determination of the major contaminants: total VOC and SVOC including separate analysis for amines and refractory compounds, acids (especially sulfate, chloride, nitrite, nitrate, phosphate) and bases (mainly ammonia)
- Active air sampling by using adsorption techniques for VOC and impinger method for ions

Cleanroom Air Evaluation

The control of air in new cleanrooms and routine monitoring during the production process are essential tasks, in all fields where clean environments for production are required: optical and laser technology, pharmaceutical industry, medical technology, life science and food.

Our portfolio includes:

- Air sampling indoors, within makeup air units, recirculation systems and in mini environments
- Careful selection of the sampling points for root cause analysis if higher level of contamination is detected
- Choice of appropriate sampling method
- Assessment of purification measures (chemical filters)
- Evaluation according to current international technology roadmap for semiconductors (ITRS) specifications

Ultrapure Water (UPW) Technology



Ultrapure water generation system



Piping for ultrapure water

Growing Requirements on Water Quality

The process and the product quality can be affected by contaminated rinsing water that contains different organic and inorganic contaminants. By integrating all technologies for water purification, the purity of water is upgraded to an ultra-high level by removing particles, organic and inorganic components as well as gases that are dissolved. The semiconductor industry requires increasingly stringent tolerance limits for contaminants in ultrapure water, especially for critical metals and TOC (see ITRS).

Guaranteed Purity of Water in Production Areas

Ultrapure water is essential to semiconductor fabrication, whereby complex and specific technologies require a great amount of water at every stage of the wafer manufacturing process. Within the immersion lithography ultrahigh purified water is used as a part of the optical system.

UPW Analysis Services

Our laboratory offers several services in analyzing critical parameters and monitoring of ultrapure water systems. To ensure the high quality of analysis the M+W Products laboratory is linked to an in-house ultrapure water facility.

Our services in analysis of ultrapure water include:

- Anions and cations with detection limits in the ppt range
- Trace metals down to the sub-ppt range
- TOC determination down to 0.1 ppb
- Particle measurement down to particle size of 0.05 μm
- Determination of water resistivity, bacteria and silica loading
- Conformity evaluation according to ITRS and customer specifications

Ultrapure Water is used in large Quantities within a wide Range of Applications:

LCD industry	Cleaning LCD components
Pharmaceutical industries	Production and constituent of drug preparations
Power stations	Stable operation of steam generators for power generating turbines
Laboratory applications	Basis for ultra-trace analysis: reagent preparation, high-purity rinsing medium, water as reactant
Solar branch	Cleaning cover glasses and silicon wafers
Life Science industry	Product constituent and using within production processes

Water Trace Analysis



Ultrapure water system



Sample bottles

Quality Control of Ultrapure Water (UPW)

The services of our analytical laboratory start with the qualification of water quality within the UPW infrastructure after installation.

We evaluate and verify the water quality in process systems and mini environment POE (point of entry) as routine services:

- Qualification of UPW systems
- Routine quality monitoring of ultrapure water within the UPW infrastructure to ensure the performance criteria
- Consultancy on chemical and technical issues with regard to UPW quality control
- Conformity evaluation according to ITRS, SEMI and customer specifications

Performance Check of Systems for Media Conditioning

Quality monitoring of ultrapure water systems is essential in semiconductor and other industries to ensure the performance criteria during production.

Our services include:

- Test of water quality in a process tool or mini environment for UPW conditioning
- Testing the water quality in the overall system from point of entry (POE) to point of use (POU)
- Controlling water quality at several transfer points
- Pre-qualification of ultrahigh purity (UHP) polymer materials (tubes, hoses, membranes etc.) for UPW distribution systems by static or dynamic leach out tests
- Validation of ion exchange resins and filter systems used for UPW systems

Filter Technology



Chemical filter materials



Preparation of filter test

Chemical Filter Technology

Chemical filters are used in a wide variety of applications for the contamination control of ambient and circulating air. Monitoring and filtration are usually done in the ppb range.

The laboratory of M+W Products offers comprehensive service for testing new as well as proofing of chemical filter materials that have to meet the highest quality requirements. The development of filter materials is focused on removal of all kinds of acidic, basic and organic substances.

Our laboratory is equipped with several test rigs and air handling units with precise air conditioning for filter tests:

- Dosage of various test substances for simulating relevant cleanroom contaminations (e.g. SO_2 , H_2S , NH_3 , NO_x , TMB, ozone and others) can be realized
- Testing of several filter materials: modified charcoal, ion exchange raisins, modified inorganic adsorbent materials and others
- Online measurement devices as well as offline sampling (impinger method and adsorbent tubes) are available

Filter Testing & Development

In collaboration with M+W Products, the laboratory supports the development and testing of new air filtering materials and concepts.

The available test rigs and installations with air handling units with adjustable air conditioning (temperature, humidity) enable reliable and standardized testing environments for various air filter systems.

Standard tests can be performed with controlled metering units of cleanroom relevant contaminations (e.g. SO_2 , H_2S , NH_3 , NO_x , TMB, ozone and others). Other chemicals can be tested on customer request.

The filter testing program provides results about:

- Advanced sampling procedure to handle higher pressure and flow
- Determination of removal efficiency
- Filter capacity
- Remaining life time test after a time period of using within its life time cycle
- Filter stability
- Ability for regeneration
- Outgassing behavior of filter materials and components

Control of Media



Gas supply systems



Media purification systems

Quality Control of Gaseous Media

Pure gases are used in many fabrication processes in the semiconductor, LED, flat panel and optical industry. They are used as purging gases for cleaning and setting up inert atmospheres, dilution and carrier gas, reaction gases and pneumatic drives. For most processes pure and ultrapure qualities are required.

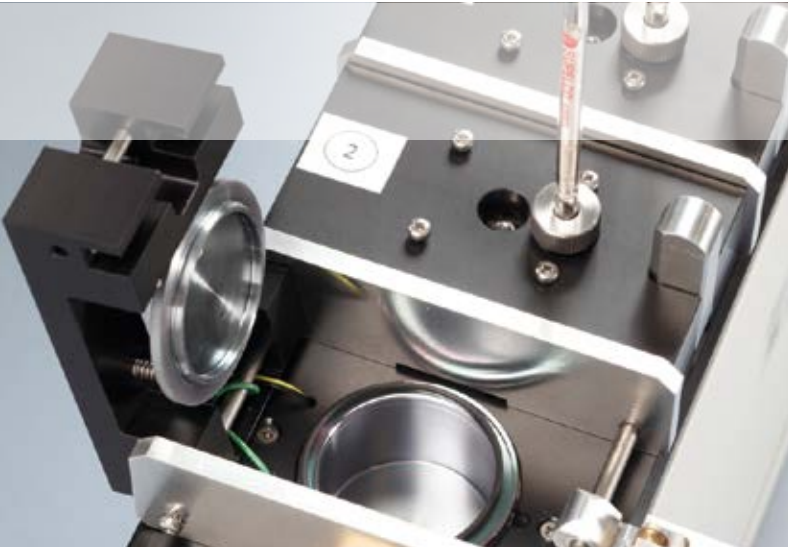
Avoiding disastrous effects on product quality and process flow, high purity gases should be continuously analyzed and monitored. Therefore, we offer:

- Analysis of clean dry air (CDA), N₂, He, Ar, CO₂ and others
- Advanced sampling procedure to handle higher pressure and flow
- Sample collection by impinger method for ion chromatography (IC) and ICP-MS analysis
- Sample collection of organic compounds and refractories by sampling with adsorption materials (e.g. Tenax, CarboTrap) and TD-GC/MS analysis



Typical schematic of a cleanroom used in semiconductor industry

Material Testing



Micro-Emission chamber for outgassing tests



Thermodesorption-tubes for GCMS analysis

Prequalification of Materials

Reducing all kinds of air contamination is a main goal in manufacturing of contamination-sensitive products like wafers, optics, lasers and processes like extreme ultraviolet (EUV) lithography.

Outgassing from materials and devices for cleanroom equipment (e.g. construction materials, floor coatings, sealing compounds, installation, consumables) is the most significant contamination source for volatile organic compounds (VOC). Analysis of outgassing behavior of materials used in clean environments is a first important step to minimize the emission potential of AMC and to improve the indoor air quality.

Material Outgassing Studies

The concentration of airborne molecular contaminants is a relevant cleanliness factor and has a significant impact on production processes and product quality. Especially the major emitters VOC and ammonia are of substantial interest.

Our AMC measurement and evaluation procedure encompasses:

- Outgassing test for organic compounds (VOC+SVOC) according to M+W guidelines and VDI 2083-17 standard
- Evaluation corresponding to M+W acceptance criteria for cleanrooms and mini environments
- Determination of material-specific standardized ISO - AMC_m class as well as ISO - AMC_{CR} class for actual cleanrooms
- Analysis by thermal desorption (TD)-GC/MS
- Issuing a M+W certification for tested equipment, materials, components and products
- Registration of tested and certified material in the M+W material data base



Cleanroom[®]
Suitable
Materials

M+W Group

Industrial Alliance
Membership

Component & Product Testing



Preparation of leaching test



Rapid transfer system – made by M+W

Test of Materials used for UPW Distribution Systems

Polymer materials and components used in UPW distribution systems are potential sources of contamination that can negatively affect the water quality. For that purpose ultrahigh purity (UHP) polymer materials that are used within the production process have to fulfil precise SEMI standard specifications. Therefore, the pre-qualification of these materials is indispensable before they are used within UPW systems.

The following material testing procedures are provided by our laboratory:

- Static leaching test of tubing, piping, membranes, valves, O-rings according to SEMI F40 in cleanrooms class 5
- Test conditions 85 ± 5 °C, 7 days (other test conditions can be applied)
- Analysis of ionic, metallic and organic contamination
- Determination of particle contamination in a rinse test according to SEMI F104
- Evaluation of compliance with SEMI F57 contamination specifications
- Dynamic leaching tests, i.e. continuous flow for classification of UPW through a part or assembly, according to SEMI standards and customer specifications

Product & Process Control for Optical and Laser Devices

Besides the importance within semiconductor industry, clean environments are also essential in the manufacturing of optoelectronic products (LEDs) and laser systems as well as in applications like laser metrology. Outgassing of organic compounds, especially condensable compounds were identified as the main source for deterioration of optics. Organic contamination can lead to hazing on surface of optics, degradation of the coating, reducing the signal transmission or the laser signal itself and can enhance the probability of laser damage.

Sources of organic outgassing can be seals, circuit boards, cable insulation, cleaning agents, coatings, resins and others. Critical compounds are siloxanes, aromatic amines and-, high boiling aromatic hydrocarbons like phthalates.

The product and process control includes:

- Component and material testing for production control
- Screening analysis of organic compounds by thermal desorption
 - Analysis of total VOC
 - Evaluation of low, medium and high boiling organic compounds
- Issuing of M+W Products certificates

Analysis Methods

Chemical Analysis for Organic Contamination

Our laboratory is equipped with state-of-the-art analytical equipment and calibrated instruments. All analytical tests are conducted using standardized or in-house procedures. We provide gas chromatography with mass spectrometry (GC/MS) equipment for the quantification and identification of organic compounds and an online TOC analyzer for the determination of organic compounds in ultrapure water.

Thermal Desorption Gas Chromatography coupled with Mass Spectrometry (TD - GC/MS)

Gas chromatography-mass spectrometry coupled with a thermal desorption unit is a universal method for the identification and quantification of a wide range of volatile as well as semi-volatile organic compounds in complex chemical environments. Air samples are collected on thermodesorption tubes packed with one or more solid adsorbents. Within a semi-quantitative screening analysis total organic compound quantities will be reported as well as the most abundant peaks can be identified by means of mass spectra libraries.

Substance	Analytes	Sample type
Total VOC	Volatile organic compounds $\geq C_6$	Ambient and indoor air, CDA, outgassing tests of cleanroom materials, products and components chemical filter Adsorbents: e.g. Tenax TA, Carbotrap 300
Total SVOC	Semi volatile organic compounds $\geq C_{16}$	
Organic amines	Aliphatic and aromatic amines, amino alcohols, amides	
Special individual compounds	PGMEA, ethyl lactate	
Refractory compounds	Organic compounds with heteroatoms (except N,O): e.g. Si, S, P, F, Cl	
Typical limits of quantitation (LOQ)*		0.01 - 0.1 $\mu\text{g}/\text{m}^3$ in air

*The LOQ in air can vary depending on the sampling time and rate and will be adjusted corresponding to the project requirements. LOQ corresponds to reference standard n-Hexadecane.

Total Organic Carbon (TOC)

Our highly-sensitive on-line TOC analyzer provides continuous monitoring of organics in ultrapure water and is able to deliver high-quality results down to a TOC concentration of 0.1 ppb. It enables quick and accurate measurements on-site to ensure the relevant demands for water quality. The analyzer will be installed directly at the place of measurement and the concentrations can be recorded directly on the device.

Individual samples, e.g. aqueous extracts, can be filled in sample vials and analyzed in a special offline mode.

Analysis	Analysis medium	Measuring range
TOC	ultrapure water (UPW)	0.1 - 2,500 ppb

Chemical Trace-Analysis for Metals and Ions

For the determination of elemental contamination in the ppt range, ICP - MS is the method of choice. Ion chromatography is applied if the concentration of ionic species (anions, cations) in water is in focus.

Inductively Coupled Plasma Mass Spectrometry (ICP - MS)

Inductively coupled plasma mass spectrometry (ICP - MS) is an elemental analysis technique for quantitative trace element analysis. It can detect almost all elements of the periodic table.

Our ICP - MS system has an excellent sensitivity and can operate down to sub-ppt limits, lower than most other analytical methods.

Substance class	Analytes	Sample type
Trace elements and dopants	Au, Ag, Al, B, Ba, Ca, Co, Cr, Cu, Fe, Ga, Ge, Hf, K, Li, Mo, Mg, Mn, Na, Ni, P, Pt, Sr, Ti Zn,	<ul style="list-style-type: none">• Ultrapure water (UPW)• UPW impinger for air samples• Diluted aqueous samples
Typical limits of quantitation (LOQ)*		1 - 10 ng/L in UPW 0.01 - 0.05 µg/m ³ in air

*The LOQ in air can vary depending on the sampling time and rate and will be adjusted corresponding to the project requirements. Lower LOQ < 1 ppt in UPW are available on request.

Ion Chromatography (IC)

Ion chromatography is the ideal method for analyzing anions, cations and other polar substances in aqueous media. A specific instrument design allows the simultaneous analysis of anions and cations from the same sample. Using a specific pre-concentration technique enables ultra-trace analysis down to the lower ppt-range.

Substance	Analytes	Sample type
Acids/anions	F ⁻ , Cl ⁻ , Br ⁻ , NO ₂ ⁻ , NO ₃ ⁻ , ClO ₃ ⁻ , SO ₄ ²⁻ , PO ₄ ³⁻ , formiate, acetate, oxalate	<ul style="list-style-type: none">• Ultrapure water (UPW)• UPW impinger for air samples• Diluted aqueous samples
Bases/cations	NH ₄ ⁺ , NH ₃ , Li ⁺ , Na ⁺ , K ⁺ , Mg ²⁺ , Ca ²⁺	<ul style="list-style-type: none">• Ultrapure water (UPW)• UPW impinger for air samples• Diluted aqueous samples
Typical limits of quantitation (LOQ)*		1 - 10 ng/L in UPW 0.01 - 0.05 µg/m ³ in air

*LOQ can vary depending on sampling time and rate, impinger volume and enrichment factor. They will be adjusted corresponding to the project requirements.

Analysis Methods

Online AMC Measurements

On-line analyzers are generally used for analyzing gaseous media. They enable fast and continuous analysis with real-time response of airborne molecular contamination and provide results with high accuracy and precision. Using our online analyzers simplifies the test setup and sampling process and make enables an enormous time saving.

Substances of interest	Analysis technique	Measuring range
SO ₂ /H ₂ S/DMS	Chemiluminescence detector	0.5 - 1,000 ppb
NO/NO ₂ /NO _x		
NH ₃		
Ozone		
Organic compounds	FID	0 - 10,000 mg C/m ³

Filter Test Installations

Our laboratory is equipped with several filter test rigs. Using high precision dosing options for gases and solvents like NO_x, SO₂, H₂S, DMS, HCl, NH₃, ozone, siloxanes, toluene, xylene and IPA nearly any kind of contamination relevant to cleanrooms can be simulated. Our online measurement equipment measures gas concentrations, temperature, humidity, air flow rate as well as pressure drop.

Test installation	Analyses	Specifics
Filter test installation	Testing of AMC filters on <ul style="list-style-type: none"> • filter efficiency • capacity • life-time 	<ul style="list-style-type: none"> • High precision dosage of several gaseous media and solvents • Online gas analyzers • Offline sampling by impinger and adsorption materials for analysis by ion chromatography and TD-GC/MS
Air handling units	Testing of AMC filter materials on capacity in long-term testings	<ul style="list-style-type: none"> • Outgassing tests of tool and ceiling filters as well as construction materials
Outgassing test installation	AMC outgassing tests for filter materials	<ul style="list-style-type: none"> • AMC sampling by impinger and adsorption materials and analysis by ion chromatography and TD-GC/MS

Particle Measurement

Available laser-based particle counters are used for measuring the particle concentration in air and water. Our laser particle counters specifically designed for particle measurements in air or water can count and size particles as low as 0.1 µm in air and 50 nm in water respectively.

Analysis	Analysis medium	Measuring range
Particles	UPW	≥ 0.05 µm
Particles	air	≥ 0.1 µm

Customer Services

We offer our customers a reliable and competent service in a wide range of specialized chemical analytics.

- Scientific advices and consultancy on chemical and technical issues with regard to contamination control
- Task oriented process development according to customer requirements
- Assistance in selecting cleanroom suitable materials and filter materials
- Fast turnaround time for sample analysis according to customer needs
- Qualified air and water sampling by trained laboratory staff
- Solution-oriented and time/cost effective sampling and analysis program in order to minimize the impairment of production process
- Preparation and delivery of sampling equipment or on-site sampling service
- Customer training on-site in applying air sampling techniques and water sampling procedures
- Test report including evaluation according to ITRS and SEMI
- Quick response and fast support for contamination issues
- M+W Products certification of VOC critical products and components
- Outgassing evaluation according to CSM guidelines

Our laboratory is a member of the CSM network and therefore works according to the guidelines and standards of CSM.




M+W GROUP

Material Outgassing Certificate

Hereby we confirm that the

Coating material

Manufactured by

John Doe Ltd.
123 Anywhere Street
Anytown, State 12345

was tested according to M+W Products standard outgassing procedure and fulfills the M+W Products specifications for semiconductor cleanrooms for above 50% coverage of the net cleanroom area.
This certificate is valid for a period of three years from date of issue.

Outgassing Results

∑(VOCs+SVOCs)	[µg/g]	9.4
TVOCs	[µg/g]	6.1
SVOCs	[µg/g]	3.3
Amines	[µg/g]	< 0.1
Organophosphates	[µg/g]	< 0.1

Detailed information can be obtained from M+W Products test report number 131154ae.
November 29, 2013

Executed by 
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CERT
ISO 9001

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