



# Homeland Security

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## Science and Technology

### **Environmental Assessment of Proposed NYC Subway Tracer Particle and Gas Releases for the Underground Transport Restoration (UTR) Project**

**Prepared for Department of Homeland Security Science and Technology  
Directorate**

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## EXECUTIVE SUMMARY

This Environmental Assessment (EA) documents the analysis of the potential effects from proposed tests involving the release of low concentrations of particles and gases at three stations within the Metropolitan Transit Authority (MTA) New York City Transit (NYCT) subway system by the Department of Homeland Security (DHS) Science & Technology Directorate (S&T). No construction, permanent land disturbance, or land use changes would occur with implementation of the Proposed Action or the Alternatives. No appreciable risk to passengers, MTA NYCT workers, or field test personnel is anticipated.

Subways are attractive targets for terrorists to release a biological weapon due to the low physical security and rapid agent dispersion from train and passenger activity. Subway dispersion models have been created to aid in understanding where biological particles travel after a release. These models help in both pre- and post-attack planning for first responders. Pre-attack planning includes identifying ideal locations for biodetection technologies. Post-attack planning includes determining the source location for attribution, identifying exposed passengers, and aiding the remediation effort (e.g., mapping, decontamination). While the subway dispersion models are critically important for homeland defense, there is little quantitative evidence as to their accuracy due to limited testing.

DHS S&T is currently leading the Underground Transport Restoration (UTR) project, a large scale effort to increase U.S. subway system resiliency against potential aerosolized biological agent attacks. Key stakeholders taking part in the effort include the Environmental Protection Agency (EPA), major transportation authorities (e.g., MTA NYCT), the federal government (e.g., DHS Office of Health Affairs), and several national laboratories. As part of this effort, DHS S&T proposes releasing particle and gas materials (“tracers”) within the MTA NYCT subway system to help refine and/or validate the statistical confidence of subway dispersion models developed by Argonne National Laboratory (ANL) with past DHS S&T funding. The motivation for the current testing derives from previous tests and modeling extrapolation having large uncertainties with respect to the effect of fomite transport (e.g., particle attachment to passenger clothing), particulate surface deposition and particle resuspension. The current assessment will analyze the potential for impacts to human health and the environment from the proposed testing, and is being coordinated with the aforementioned stakeholders and the public ridership for information and comment. This environmental assessment is being conducted in accordance with the National Environmental Policy Act (NEPA) as outlined in 40 CFR Parts 1500-1508 and DHS Directive 023-01, Environmental Planning Program.

The tests are planned for the Spring of 2016 and must be conducted during revenue hours to understand the quantitative impact on dispersion from train cars and passenger movement. Gas material is proposed for release concurrently with particulate material. A gas simulant provides highly specific real-time concentration data (difficult to do with particulates) and the ability to correlate the UTR measurements to previous gas tracer testing conducted in the MTA

NYCT subway system. In addition, gaseous materials do not deposit on surfaces and are unaffected by mechanical filtration in train car HVAC systems thereby providing an indication of particulate losses through these actions.

In total, there are two safe particulate alternatives presented in this assessment, which would meet the needs of DHS S&T. Regardless of the particulate material, the release dissemination is proposed for subway revenue hours (i.e., operational) because the main effects being tested are the impact of the trains and passengers on dispersion model predictions. The two particulate tracer alternatives are shown below as well as a no particulate alternative:

- Particulate Tracer Alternative P1: Aerosol release of DNA oligonucleotides (oligos) encapsulated in soluble maltodextrin particles (maltodextrin with oligos is referred to commercially as DNATrax) and tagged with a fluorescent Optical Brightener (referred to as DNATrax-OB). DNATrax-OB allows for quantification using PCR and fluorimetry, but not culture methods.
- Particulate Tracer Alternative P2: Aerosol release of P1 attached to amorphous silica particles (referred to as DNATrax-OB-Silica). DNATrax-OB-Silica allows for quantification using PCR and fluorimetry, but not culture methods.
- Particulate Alternative P3: No particulate released.

Alternatives P1 and P2 present similar options; P2 uses amorphous silica as a carrier to afford tighter particle size control. Characterization work (e.g., limit of detection measurements, sizing capabilities, reaerosolization chamber tests) is ongoing to determine whether P1, P2, or a combination is preferred for releases. However, both DNATrax-OB and DNATrax-OB-Silica do not present a significant risk to the environment or human health. The no particulate alternative will not help to validate current particulate models and therefore does not meet the needs of the development effort and test.

DNATrax presented in Alternative P1 was developed for food labeling and has been classified by the Food & Drug Administration (FDA) as Generally Recognized As Safe (GRAS). The primary component maltodextrin is used in several commercially available food products such as sweetening agents (e.g., Splenda®) and protein shakes. The DNA oligo sequences, selected from natural sequences, do not produce proteins and are considered to be safe. The Optical Brightener (OB) is also considered safe and is used commercially in detergents, cosmetics and paper products. Amorphous silica, the primary component in Alternative P2, is used as an anti-caking agent and a carrier for liquid active ingredients in human and animal nutrition.

While most of these materials have been shown to be safe in many consumer food products, the material will be aerosolized in a respirable form (particle sizes from 1 – 10 µm) resulting in many passengers breathing the material into their lungs rather than ingesting. Both DNATrax-OB and DNATrax-OB-Silica usage will result in air concentrations well below OSHA Permissible Exposure Levels (PELs) and American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs). Note that these values are created for

occupationally-exposed healthy individuals while some passengers may have respiratory illnesses and/or compromised immune systems. However, the small quantity of particulate material proposed for these tests will result in 8-hour maximum mass concentrations (i.e., next to release) that are over an order of magnitude lower than the established limits by OSHA and ACGIH, respectively, providing an additional margin of safety.

The gas tracer material should be safe at proposed release concentrations (e.g., tens of ppm), not currently present in the background, completely passive (i.e., non-reactive), and quantifiable to very low concentrations (ppt or lower). The three gas tracer alternatives are:

- Gas Alternative G1: Release of sulfur hexafluoride ( $\text{SF}_6$ ) gas within the subway system. Sulfur hexafluoride allows for real-time measurements using infrared spectroscopy and laboratory measurements using Gas Chromatography Mass Spectroscopy (GC-MS).
- Gas Alternative G2: Release of  $\text{SF}_6$  gas and three perfluorocarbon tracers (PDCB, PMCH, and mPDCH). The three perfluorocarbon tracers allow for higher sensitivity compared to  $\text{SF}_6$  due to their extremely low presence in the subway background.
- Gas Alternative G3: No gas released.

Notice that there is an alternative that would involve no gas releases. A gas simulant provides highly specific real-time concentration data (difficult to do with particulates), the ability to correlate the UTR measurements to previous gas tracer testing conducted in the MTA NYCT subway system, and a reference for particle filtration and deposition within the system since the gas simulant is not mechanically filtered (e.g., train HVAC filters) or deposited on surfaces. However, the primary objective of the current test is to evaluate particulates, rather than gases.

Seven perfluorocarbon tracers (known as PFTs) were safely used for the Subway Surface Air Flow Exchange (S-SAFE) Program (i.e., 2013 NYPD funded gas tracer study). Three of those same seven PFTs or related isomers are proposed for Alternative G2. While  $\text{SF}_6$  provides real-time measurement capabilities near the release location, the sensitivity of measurements past a few stations from the release location will be limited due to the relatively high  $\text{SF}_6$  concentrations that are always present in the NYC subway background (due to leakage from electric power substations). All of the proposed gases have been demonstrated as safe for this application and have been released in populated subway stations previously with no reported adverse effects. Therefore, Alternative G2 would be the preferred plan for the proposed measurements.

The indirect environmental effects caused by the potential exposure of terrestrial wildlife by movement of the material out of subway tunnels and into the open air were also evaluated. The environmental consequences posed by any of the alternatives as outlined will not have an adverse effect on terrestrial wildlife.

In accordance with Executive Order 12898, analysis of the environmental effects must also include effects on minority communities and low-income communities, when such analysis is required by the National Environmental Policy Act of 1969 (NEPA), 42 U.S.C. section 4321 et

esq. There is no evidence that low income or minority populations would receive a higher exposure to the particulate or gas material than any other group. In the case that these groups have a higher prevalence of “sensitive” populations (e.g., asthmatics), maintaining similar levels to EPA-established National Ambient Air Quality Standards and being well below established gas thresholds illustrates that these alternatives would not disproportionately impact minority or low-income communities.

DHS S&T will post the EA with an email address for the public to comment over a 6-week period in the fall/winter, 2015. Public input submitted will be discussed and considered with respect to conclusions of the EA.

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## LIST OF ACRONYMS

AAC – Acceptable Air Concentration  
ACGIH – American Conference of Governmental Industrial Hygienists  
ANL – Argonne National Laboratory  
*Ba* – *Bacillus anthracis*  
BGM – Below Ground Model  
BRL – Below Reporting Limit  
CAS – Chemical Abstracts Service  
CDC – Center for Disease Control  
CFR – Code of Federal Regulations  
CFU – Colony Forming Unit  
CO – Carbon Monoxide  
CO<sub>2</sub> – Carbon Dioxide gas  
COPD – Chronic Bronchitis/Chronic Obstructive Pulmonary Disease  
DfT (UK) – Department for Transport United Kingdom  
DHS S&T – Department of Homeland Security Science & Technology Directorate  
DNA – Deoxyribonucleic Acid  
DNATrax – DNA Tagged Reactants for Aerosol Experiments  
DSTL – Defence Science and Technology Laboratory  
DTRA – Defense Threat Reduction Agency  
EC<sub>0</sub> – No-Effect Concentration  
EC<sub>50</sub> – 50% of Maximal Effect Observed  
eDNA – environmental DNA  
EPA – Environmental Protection Agency  
ETAD – Ecological & Toxicological Association of Dyes & Organic Pigments Manufacturers  
FDA – Food & Drug Administration  
GC-MS – Gas Chromatography Mass Spectroscopy  
GCT – Grand Central Terminal  
GRAS – Generally Recognized As Safe  
GWP – Greenhouse Warming Potential  
HH – Health Hazard  
HPV – High Production Volume  
HVAC – Heating, Ventilation & Air Conditioning  
iPPCH – Perfluoroisopropylcyclohexane  
LC<sub>0</sub> – Maximum Tolerable Dose  
LLNL – Lawrence Livermore National Laboratory  
MBTA – Massachusetts Bay Transportation Authority  
MIT LL – Massachusetts Institute of Technology Lincoln Laboratory  
MMAD – Mass Median Aerodynamic Diameter  
mPDCH – Metaperfluorodimethylcyclohexane  
MTA – Metropolitan Transportation Authority  
MTCDE – Metric Tons Carbon Dioxide Equivalent

NAAQS – National Air Quality Standards  
NEPA – National Environmental Policy Act  
NOAA - National Oceanic and Atmospheric Administration  
NYCCAS – New York City Community Air Survey  
NYCT – New York City Transit  
NYSHPO – New York State Historic Preservation Office  
OB – Optical Brightener  
OSHA – Occupational Safety and Health Administration  
PCR – Polymerase Chain Reaction  
PDCB – Perfluorodimethylcyclobutane  
PEL – Permissible Exposure Limit  
PFT – Perfluorocarbon Tracer  
PM<sub>10</sub> – Particulate Matter under 10 microns  
PM<sub>5</sub> – Particulate Matter under 5 microns  
PM<sub>2.5</sub> – Particulate Matter under 2.5 microns  
PMCH – Perfluoromethylcyclohexane  
PNOS – Particle Not Otherwise Specified  
PPMv – Parts Per Million by Volume  
PPE – Personal Protective Equipment  
PPL – Particles Per Liter of Air  
PPTV – Parts Per Trillion by Volume  
PTCH – Perfluorotrimethylcyclohexane  
ptPDCH – Perfluoroethylcyclohexane  
RCRA – Resource Conservation and Recovery Act  
SAS – Synthetic Amorphous Silica  
SDS – Safety Data Sheet  
SF<sub>6</sub> – Sulfur Hexafluoride  
S-SAFE – Subway Surface Air Flow Exchange  
SCOGS – Select Committee on GRAS Substances  
TLV – Threshold Limit Value  
TSP – Total Suspended Particulates  
TWA – Time Weighted Average  
UDP – Urban Dispersion Program  
USDA – U.S. Department of Agriculture  
UTR – Underground Transportation Restoration  
WHO – World Health Organization  
WMATA – Washington Metropolitan Area Transit Authority

## Section 1. Purpose and Need of the Proposed Action

A strategic goal of the U.S. Department of Homeland Security (DHS) is to prevent, detect, protect and recover from biological attacks<sup>1</sup>. Protecting and remediating critical infrastructure, such as subways, from the effects of biological weapons is a key element to achieving this goal. Early warning detection systems (e.g., BioWatch Program), rapid response strategies (e.g., stop trains, evacuation), and post-attack remediation strategies (e.g., mapping contamination) are constantly being examined for subway systems to minimize casualties and economic impact. Subway dispersion models have been created to help in these endeavors and are actively used by agencies within DHS for both pre- and post-attack planning. Pre-attack planning includes identifying ideal locations for biodetection technologies. Post-attack planning includes determining the source location for attribution, identifying exposed passengers, and aiding the remediation effort (e.g., mapping, decontamination). While the subway dispersion models are critically important for homeland defense, there is little quantitative evidence as to their accuracy due to limited testing.

Previous subway dispersion tests are shown in TABLE 1; many of the previous efforts have focused on gases and liquid aerosols. These types of measurements lack information on reaerosolization, train car mechanical filtration, and fomite transport (i.e., attachment and subsequent resuspension of particulate materials on passengers and their personal effects). Solid particulate measurements that do exist have limited spatial area results (i.e., limited to 1 – 2 stations) due to sensitivity and specificity issues (e.g., poor limit of detection). In general, all previous tests lack the spatial and temporal resolution desired for model validation.

Without meaningful validation under realistic threat scenarios, the actual measure of protection current dispersion models provide is academic rather than demonstrated. The proposed testing action will determine the accuracy and sensitivity of current subway dispersion models.

The purpose of this Environmental Assessment is to evaluate whether significant impacts to the environment may occur from the proposed dispersion testing. DHS S&T proposes to test dispersion model accuracy in the MTA NYCT subway system using small quantities of carrier particles tagged with DNA oligonucleotides (oligos) and an Optical Brightener (OB). Tagging carrier particles with oligos allows for highly specific and sensitive measurements to be made, thus fulfilling the purpose of the proposed dispersion tests. There are two choices of carrier particles currently being assessed: maltodextrin and amorphous silica. The combination of maltodextrin with oligos is a commercially available product called “DNATrax”. Both DNATrax and amorphous silica have been used for tracer testing in public spaces previously. In addition, three perfluorocarbon tracer (PFTs) and SF<sub>6</sub> gases are proposed for concurrent release. All four gas materials have previously been used for tracer testing in subways during revenue hours (i.e., passengers present). This assessment will examine the impact of using the proposed particulate and gas materials with respect to human health and environmental safety.

**TABLE 1**  
**Previous Subway Revenue-Hour Particulate and Tracer Gas Material Phenomenology Measurements**

| Year        | Agency / Program                | Sponsor       | Gas                     | Particulate               | Location           | Limitations   |
|-------------|---------------------------------|---------------|-------------------------|---------------------------|--------------------|---|
| 1966        | U.S. Army                       | U.S. Army     | ---                     | <i>B. atrophaeus</i> (BG) | MTA NYCT           | Lack of particle size information, limited spatial extent, no surface sampling, lack of specificity |
| 2005        | Urban Dispersion Program (UDP)* | DHS, DTRA     | 7 PFTs, SF <sub>6</sub> | ---                       | MTA NYCT           | No particulates   |
| 2006        | MetroGuard Testing              | MTA NYCT      | ---                     | Polystyrene, Urea         | MTA NYCT           | Limited spatial resolution (one station)  |
| 2007 – 2008 | ANL, LBNL                       | DHS           | 3 PFTs, SF <sub>6</sub> | Urea                      | DC WMATA           | Liquid aerosol droplet, lack of sensitivity/specificity   |
| 2009 – 2012 | ANL, LBNL                       | DHS           | 3 PFTs, SF <sub>6</sub> | Urea, Silica              | Boston MBTA        | Liquid aerosol droplet, lack of sensitivity/specificity   |
| 2013        | DSTL, ANL, LBNL, BNL            | DfT (UK), DHS | 5 PFTs, SF <sub>6</sub> | Urea                      | London Underground | Liquid aerosol droplet, lack of sensitivity/specificity   |
| 2013        | S-SAFE* Program                 | NYPD          | 7 PFTs                  | ---                       | MTA NYCT           | No particulates   |

\*UDP and S-SAFE phenomenology measurements included BNL and ANL

## **Section 2. Text Alternatives to Meet the Need**

This section will detail the range of test simulant alternatives to determine the Proposed Action for the particulate and gas materials. The analysis of the alternatives is being conducted in accordance with the National Environmental Policy Act (NEPA) as outlined in 40 CFR Parts 1500-1508 and DHS's implementing regulation Directive 023-01, Environmental Planning Program.

The optimum condition for executing a bio-terror attack would be during rush hour, when a large number of riders are in the stations and trains are running at peak number and speed. The transport of aerosols is largely driven by the motion of trains and passengers in the system, and thus the most accurate reflection of material transport would involve testing when stations are operational.

Therefore, all particulate and gas release alternatives are proposed during revenue hours (i.e., during normal operations while passengers are present within station) in Grand Central, Times Square, and/or Penn Station. These stations were selected due to having crossing subway lines, high passenger traffic, and significant psychological importance. The area immediately around the specific release location will be roped off with field test personnel (including MTA and NYPD personnel) blocking entrance. A "release event" will include both particulate and gas materials being released at two separate stations simultaneously for 10 – 20 minutes. The amounts of particulate and gas materials released per release event will be discussed in the next few sections. Each release event will be separated by a minimum of 23 hours. A total of five release events are proposed over a week. TABLE 2 is an example of what the final release schedule will look like.

**TABLE 2**  
**Tentative Release Schedule\* (Subject to Revision)**

| Release Event # | Day   | Proposed Particulate & Gas Details |           |                 |        |          |            |           |        | Sampling Window | Simulant Release Window |
|-----------------|-------|------------------------------------|-----------|-----------------|--------|----------|------------|-----------|--------|-----------------|-------------------------|
|                 |       | Station #1                         | Particles | SF <sub>6</sub> | PFT #1 | PFT #2** | Station #2 | Particles | PFT #3 |                 |                         |
| 1               | Mon   | GC                                 | 20 g      | 1 kg            | 0.5 kg | 0.5 kg   | TSQ        | 10 g      | 0.5 kg | 9am – 3pm       | 11am – 12pm             |
| 2               | Tues  | GC                                 | 20 g      | 1 kg            | 0.5 kg | 0.5 kg   | TSQ        | 10 g      | 0.5 kg | 9am – 3pm       | 11am – 12pm             |
| 3               | Wed   | GC                                 | 10 g      | 1 kg            | 0.5 kg | 0.5 kg   | TSQ        | 20 g      | 0.5 kg | 9am – 3pm       | 11am – 12pm             |
| 4               | Thurs | GC                                 | 20 g      | 1 kg            | 0.5 kg | 0.5 kg   | PS         | 10 g      | 0.5 kg | 9am – 3pm       | 11am – 12pm             |
| 5               | Fri   | GC                                 | 10 g      | 1 kg            | 0.5 kg | 0.5 kg   | PS         | 20 g      | 0.5 kg | 9am – 3pm       | 11am – 12pm             |

\*Note that testing may be conducted on the weekend if one of the weekday tests was postponed due to extreme weather conditions.

\*\*PFT #2 will be released on the Grand Central – 42 St 7 Platform

GC = Grand Central – 42 St 4,5,6 Platform, TSQ = Times Sq – 42 St 1,2,3 Platform, PS = 34 St - Penn Station 1,2,3 Platform

## ***2.1 Particulate Tracer Alternatives***

The particle tracer dissemination method will be short dry bursts every 30 – 60 seconds for 10 – 20 minutes. The maximum amount of particulate tracer material released within a station over ten minutes, 8 hours, and 24 hours is 20, 20, and 40 grams, respectively. The particulate release amount has been chosen because it provides enough tracer material for sampling measurements to take place several stations away from the release location but should not create a visible plume or substantially add to the visible background haze within the stations (see Section 3.2.2 Subway Indoor Air Quality). The device used to release the material in short bursts is called an “eductor”. The particulate tracer material is stored in a plastic tube that fits into the bottom of the eductor. Compressed air will be passed over a small opening in the top of the tube which aerosolizes the particulates. The particulate tracer material will be weighed and pre-filled into the eductor plastic tube in a laboratory. The filled tubes will be placed in a shatter resistant, leak-proof sealed secondary container for transport to the test site.

Mobile equipment and samples will be used to collect particulates in the subway. The majority of air samples will be collected using Portable Sampling Units (PSUs) and Dry Filter Units (DFUs). PSU devices weigh 113 lb, are approximately 5’ × 25” × 16” (H×W×D) in size, and require electrical power (110 Volts). DFU devices weigh 42 lb, are approximately 15” × 13” × 13” (H×W×D) in size, and require electrical power (110 Volts). Approximately 40 – 60 PSUs and 40 DFUs will be temporarily located within subway stations and near station vents the week of testing. Locations have been identified where power is available. The PSU and DFU devices can be locked in place using a chain and pedestrian traffic will remain unimpeded. Units will be put into position the week before testing begins and removed the week after testing. No permanent physical changes will take place to stations or outdoor locations from the use of PSUs or DFUs.

In addition, approximately 25 – 50 portable particle counters will be placed in stations near the release for real-time particle counts. Particle counters will be locked in place and plugged into outlets for power. Units will be put into position the day of testing and removed at the end of each day of testing. No physical changes will take place to station or outdoor locations where particle counters are located.

### **2.1.1 Particulate Alternative P1**

The first particulate alternative (P1) is to aerosolize DNA oligonucleotides (oligos) encapsulated in maltodextrin particles (referred to as “DNATrax”) and tagged with an Optical Brightener (OB). DNATrax (i.e., DNA oligos encapsulated inside maltodextrin) was developed by Lawrence Livermore National Laboratory (LLNL) for food labeling and has been classified by the Food & Drug Administration (FDA) as Generally Recognized As Safe (GRAS). The Safety Data Sheet (SDS) and FDA GRAS designation letter for DNATrax have been included in Appendix A. DNATrax-OB, which includes encapsulation of both CI Fluorescent Brightener 220 and DNA oligos inside maltodextrin, is proposed as particulate alternative P1 for the

described phenomenology tests. The SDS for CI Fluorescent Brightener 220 has also been included in Appendix A.

The primary component, maltodextrin, is already used extensively in several food and drink products (e.g., beer, protein shakes, and sweeteners such as Splenda). The SDS for maltodextrin has also been included in Appendix A. The DNA oligo sequences, selected from natural sources, do not produce proteins and are considered to be safe (refer to Section 4.1 Human Health and Safety Effects). In addition, DNA is already ubiquitous in the environment and is produced by all living matter. The optical brightener, Fluorescent Brightener 220 (SDS included in Appendix A), is used in several consumer products such as laundry detergent and paper production. Maltodextrin, CI Fluorescent Brightener 220 and DNA oligos do not present a significant risk to the environment or human health.

The DNATrax-OB particles will have a mass median aerodynamic diameter (MMAD) between 1 – 10  $\mu\text{m}$ , which is considered respirable. The DNATrax-OB particles (including the primary component maltodextrin) are not listed explicitly by OSHA; therefore it is assumed classified as “Particulates Not Otherwise Regulated” by OSHA and at a minimum would be required to remain well below the designated 8-hour Time Weighted Average (TWA) respirable Permissible Exposure Limit (PEL) of 5  $\text{mg}/\text{m}^3$ . The American Conference of Governmental Industrial Hygienists (ACGIH) recently established a Threshold Limit Value (TLV) of 3  $\text{mg}/\text{m}^3$  (respirable) and 10  $\text{mg}/\text{m}^3$  (inhalable, i.e., deposits in the nose, throat and upper respiratory tract) for “particles not otherwise specified (PNOS)”. However, the ACGIH PNOS designation applies only to particles that are insoluble or poorly soluble in water (maltodextrin is soluble in water). To be conservative, air concentrations will remain well below the lower ACGIH TLV. Given that these values are created for occupationally-exposed healthy individuals, and while some passengers may have respiratory illnesses and/or compromised immune systems, the small quantity of particulate material proposed for these tests will result in 8-hour maximum concentrations (i.e. next to release) that are 500 and 300 times lower than the established limits by OSHA and ACGIH for particles not otherwise regulated (i.e., inert or nuisance dusts), respectively. For more information, refer to Section 4.1.1 Human Health and Safety Effects from Particulate Releases.

### **2.1.2 Particulate Alternative P2**

The second particulate alternative (P2) is to aerosolize P1 attached to amorphous silica particles. Particulate Alternative P2 will be referred to as DNATrax-OB-Silica. The Safety Data Sheet (SDS) for amorphous silica has been included in Appendix A.

Amorphous silica, the primary component in Alternative P2, is used as an anti-caking agent and a carrier for liquid active ingredients in human and animal nutrition.

The DNATrax-OB-silica particles will have a mass median aerodynamic diameter (MMAD) between 1 – 10  $\mu\text{m}$ , which is considered respirable. The DNATrax-OB-silica particles are primarily amorphous silica which OSHA regulates specifically; at a minimum the mass



concentration would be required to remain well below the designated 8-hour TWA respirable PEL of 0.8 mg/m<sup>3</sup>. The ACGIH recently established a TLV of 3 mg/m<sup>3</sup> (respirable) and 10 mg/m<sup>3</sup> (inhalable, i.e., deposits in the nose, throat and upper respiratory tract) for “particles not otherwise specified (PNOS)”. Given that these values are created for occupationally-exposed healthy individuals, and while some passengers may have respiratory illnesses and/or compromised immune systems, the small quantity of particulate material proposed for these tests will result in 8-hour maximum concentrations (i.e. next to release) that are 80 and 300 times lower than the established limits by OSHA and ACGIH for particles not otherwise regulated (i.e., inert or nuisance dusts), respectively. For more information, refer to Section 4.1.1 Human Health and Safety Effects from Particulate Releases.

### **2.1.3 No Action Particulate Alternative (P3)**

The no action alternative would eliminate conducting in-situ particulate releases within the subway system. Non-revenue releases cannot be conducted in the MTA NYCT system because it is continuously operational. Gas measurements (described in the next section) by themselves have already been conducted in NYC as part of the S-SAFE and UDP Programs. This alternative will not help to validate current particulate models and therefore does not meet the needs of the development effort and test.

## ***2.2 Gas Tracer Alternatives***

The gas tracers would include sulfur hexafluoride (SF<sub>6</sub>) and/or three perfluorocarbon tracers (PFTs) that would be continuously released during the ten-minute particulate release period. The release rates and amounts are listed in TABLE 3. Because SF<sub>6</sub> is a gas at room temperature, it would be released from a low-pressure cylinder through a flow meter to monitor its release rate. The PFTs, which are liquid at room temperature, would be metered onto battery-powered, low-temperature hot plates (one for each PFT) where they would quickly evaporate. Small, battery-powered fans would be used to ensure rapid dispersal of the tracer gases.

Mobile equipment will be used to collect gas samples in the subway. The majority of gas samples will be collected from the air using gas bag samplers. The gas bag samplers are custom made portable devices that weigh approximately 15 lb, are 16" × 10" × 12" (L×W×H) in size, and are battery powered. Approximately 40 gas bag samplers will be temporarily located within subway stations and near station vents the week of testing. The gas bag samplers can be locked in place using a chain and pedestrian traffic will remain unimpeded. Units will be put into position the week before testing begins and removed the week after testing. No permanent physical changes will take place to stations or outdoor locations from the use of gas bag samplers.

In addition, approximately 10 portable gas sensors will be placed in stations near the release for real-time gas concentration measurements. Gas sensors will be locked in place and

plugged into outlets for power. Units will be put into position the day of testing and removed at the end of each day of testing. No physical changes will take place to station or outdoor locations where gas sensors are located.

**TABLE 3**  
**Tracer Gas Release Amounts and Release Rates**

| Gas                                      | CAS        | Mass Released (kg) |      |       | Release Rate<br>per Event (g/min) |
|--|------------|--------------------|------|-------|-----------------------------------|
|  |            | 10-min*            | 8-hr | 24-hr |                                   |
| Sulfur Hexafluoride (SF <sub>6</sub> )   | 2551-62-4  | 1.0                | 1.0  | 2.0   | 50 - 100                          |
| Perfluorodimethylcyclobutane (PDCB)      | 28677-00-1 | 0.5                | 0.5  | 1.0   | 25 - 50                           |
| Perfluoromethylcyclohexane (PMCH)        | 355-02-2   | 0.5                | 0.5  | 1.0   | 25 - 50                           |
| Metaperfluorodimethylcyclohexane (mPDCH) | 335-27-3   | 0.5                | 0.5  | 1.0   | 25 - 50                           |

\*A gas release event will occur over a 10 – 20 minute period and will coincide with the release of the particulate tracer. The upper bound is set at 1 gas release event per day and 2 gas release events over 24-hours.

### 2.2.1 Gas Alternative G1

The first gas alternative (G1) is to use SF<sub>6</sub> alone. SF<sub>6</sub> is a biologically inert, colorless, odorless gas. The SDS for SF<sub>6</sub> has been included in Appendix A. It has been widely used as an airflow tracer for several decades in indoor and outdoor studies alike, including subway releases in Washington, DC (2007, 2008)<sup>2</sup> and Boston (2009, 2010, and 2012)<sup>3</sup> as well as aboveground releases in mid-town Manhattan during UDP (2005)<sup>4</sup>.

The OSHA PEL and the ACGIH TLV for SF<sub>6</sub> are 1,000 ppm for an 8-hour TWA. These limits were established to prevent oxygen displacement (i.e., to prevent asphyxia) rather than because of chemical toxicity. The largest 1-hour average SF<sub>6</sub> concentration measured near the SF<sub>6</sub> release location during the Boston subway tests was less than 1% of the PEL and TLV; the equivalent 8-hour concentration was more than 1,000 times less than these limits.

In addition, SF<sub>6</sub> is a greenhouse gas and has a Global Warming Potential (GWP) of 23,600<sup>5</sup>. However, the amount of SF<sub>6</sub> planned for release will have a low overall GWP impact; more discussion is provided in Section 4.3 Global Warming Potential.

Because of its stability and high dielectric constant, SF<sub>6</sub> is primarily used as an insulating gas by the electric power industry. Due to its use in electric substations, urban areas in the U.S. have considerable fugitive emission sources. For instance, in 2002 fugitive emission estimates for the U.S. amounted to approximately 720,000 kg, including 101,000 kg in NYC alone, an average of 1,942 kg per week<sup>6</sup>. In comparison, less than 20 kg total will be released in this study.

An unfortunate consequence of the fugitive emissions is that elevated background levels of SF<sub>6</sub> may compromise the tracer measurements. In January 2004, prior to the UDP study, background SF<sub>6</sub> measurements in mid-town Manhattan were made by scientists from the National Oceanic and Atmospheric Administration (NOAA) Air Resources Laboratory. These measurements revealed substantial SF<sub>6</sub> emissions from a substation in mid-town, with concentrations ranging as high as 5,209 pptv (immediately downwind of the substation) down to 167 pptv at a distance of 2.7 km. For this reason, SF<sub>6</sub> alone is not a recommended alternative.

The value of using SF<sub>6</sub> as a tracer is that its infrared signature permits detection in real time using portable infrared gas analyzers. Even in the presence of significant background levels, the real-time measurement capability would be invaluable for monitoring the concentration levels in stations near the release point during the tests and for obtaining high time-resolution data.

### 2.2.2 Gas Alternative G2

The second gas alternative (G2) is to use three PFTs in addition to SF<sub>6</sub>. PDCB, PMCH, and mPDCH are inert, odorless, and colorless. The SDS for PDCB, PMCH, and mPDCH has been included in Appendix A. They are fully fluorinated (saturated with fluorine), contain only carbon and fluorine, and have no unsaturated bonds. For these reasons, these compounds are extremely stable, chemically and physically. One result of their extreme stability is that they have few commercial uses and therefore their background concentration in the atmosphere is extremely low.<sup>7</sup> This permits very small amounts of the tracers to be detected. Because of this low background, PFTs have been used as airflow tracers for decades<sup>7</sup>, including the subway studies in Washington, DC and Boston, UDP and S-SAFE, described earlier.

Being extremely stable chemically also makes perfluorocarbon compounds biologically inert and therefore suitable for a wide range of medical applications such as blood extenders or blood substitutes<sup>8</sup>, wound healing<sup>9</sup>, eye surgery<sup>10,11</sup>, equipment sterilization, imaging<sup>12,13</sup>, liquid breathing<sup>14,15,16,17</sup>, and organ storage.

Because perfluorocarbons are not known to cause adverse health effects, even at high concentrations, no OSHA PEL, ACGIH TLV, or Acute Exposure Guideline Level (AEGL) have been established. For S-SAFE, a 15-min Acceptable Air Concentration (AAC) limit of 9 ppm and an 8-hr limit of 3 ppm were established<sup>18</sup> for the PFTs. These thresholds were based on the known toxicity profile of cyclohexane, which is an industrial solvent, not an inert perfluorocarbon compound. Nevertheless, based on the maximum observed concentrations near the PFT release locations in the Boston subway tests and the greater dilution of PFTs observed in the MTA NYCT subway during S-SAFE (owing to the larger stations and more frequent trains), the concentrations near the PFT release locations in this study should be 3 – 4 orders of magnitude lower than 8-hr OSHA PEL for cyclohexane (300 ppmv) and an order of magnitude lower than the AAC 8-hr limit. More discussion is provided in 4.1.2 Human Health and Safety Effects from Gas Releases.

As mentioned in the previous section, SF<sub>6</sub> is a greenhouse gas and has a GWP of 23,600<sup>5</sup>. The GWP of the particular PFTs proposed for this study are not published, but can be conservatively estimated as 10,000 based on the accepted range of GWP for PFTs as 1,000 – 10,000<sup>19</sup>. Using these GWPs for the tracers, the upper bound is estimated at 193 MTCDE (Metric Tons Carbon Dioxide Equivalent) or 424,600 lbs of CO<sub>2</sub> equivalent for the total amount of gas tracers proposed to be released during this study.

### **2.2.3 No-Action Gas Alternative**

The no action alternative would eliminate conducting in-situ gas releases within the subway system. Because the NYC subway operates 24 hours per day, 7 days per week, it is not possible to conduct these tests during non-revenue hours. Gas tracer releases have already been conducted in NYC as part of the S-SAFE and UDP Programs. Releasing similar gas tracers in this study will enable the data to be directly compared to the results of those previous studies. More importantly, the tracer gases do not deposit on surfaces and are unaffected by mechanical filtration in train car HVAC systems. Because the co-located gas

releases will assess the airflow and passive dispersion, simultaneous gas and particulate measurements would allow particulate removal processes to be directly quantified through comparison of the relative gas and particulate concentrations. Although the primary objectives of the proposed study could be attained solely with the release of particulate materials, the additional benefits of the gas tracer measurements are substantial. This is particularly true if the results do not agree with the currently existing computational models. While the No-Action Gas Alternative would still allow the primary objectives of the tests to be met, it is not recommended.

## **Section 3. Affected Environment**

Several U.S. subway systems were considered to host the measurements. The three main criteria in selecting a venue for this study were as follows:

- A large system with many underground stations and multiple subway lines;
- A system representative of many other subway systems;
- A system in which research studies on the modeling of airflows, particle transport dynamics, and assessments of normal background conditions have been previously carried out.

After preliminary discussions were held with a few subway systems, the MTA NYCT was considered to be an optimal location. The MTA NYCT is the largest U.S. subway system and contains several types of stations. They have hosted several previous chemical and biological defense related projects and have been an extremely amenable host. In addition, an extensive chemical tracer study was recently completed that can be leveraged for further information (2013 S-SAFE Program).

Within the MTA NYCT system, there are three potential subway stations chosen for releasing tracer materials: Grand Central, Time Square, and Penn Station. These stations were selected due to having crossing subway lines, high passenger traffic, and significant psychological importance.

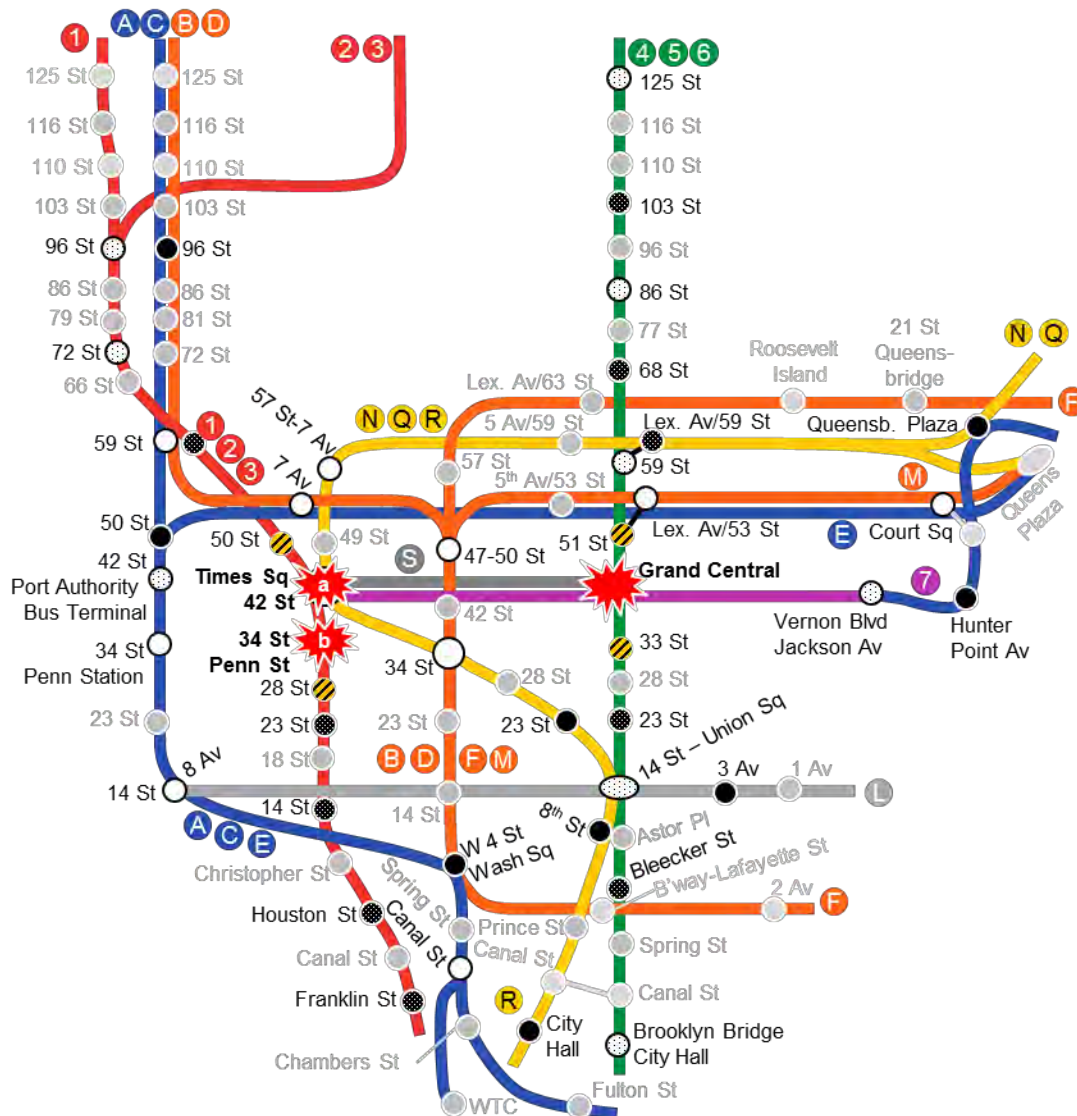
### ***3.1 MTA NYCT Subway Overview***

The MTA NYCT subway system is the nation's largest mass transit system in terms of daily ridership (> 6 million), number of stations (468), and total track length (842 miles). It has 34 physical lines and is continuously operational (i.e., 24/7, 365 days a year).

Times Square, Grand Central, and Penn Station rank amongst the top 5 busiest stations in the MTA NYCT subway system<sup>20</sup> and were therefore chosen as possible releases sites. Grand Central is located in Midtown Manhattan at the intersection of Park Avenue and 42<sup>nd</sup> Street. The MTA platforms lie beneath Grand Central Terminal, which serves all Metro-North Railroad

lines east of the Hudson River. Penn Station is situated completely underground and is located underneath Madison Square Garden, 33<sup>rd</sup> Street, and Two Penn Plaza. The station spans three underground levels with the concourses located on the upper two levels and the train platforms located on the lowest level serving Amtrak, Long Island Railroad, New Jersey Transit and the MTA subway (1,2,3 and A,C,E platforms). Times Square station is located under Times Square and the Port Authority Bus Terminal, at the intersection of 42<sup>nd</sup> Street, Seventh and Eighth Avenues, and Broadway in Midtown Manhattan. Five different subway lines are served at Times Square station including the S, 7, (1,2,3), (N,Q,R) and (A,C,E) lines.

Sampling will occur at stations adjacent to the identified release sites (red stars shown in Figure 1), as well as platforms up to 10 – 12 stations away. Proposed stations and subway lines for sampling are listed in TABLE 4.



### Legend

|   |  |
|---|--|
| ● Local train station (Air sampling* indoors)   | *Sampling typically indicates:<br>• Air: PSU and/or DFU<br>• Surface: 8 12x12" Alum. coupons<br>• Gas: 1 Gas box |
| ● Local train station (Air/surface sampling* indoors)                                   |  |
| ○ Local & express train station (Air sampling indoors)                                  |  |
| ○ Local & express train station (Air/surface/gas sampling indoors)                      |  |
| ▨ Adjacent release station (Air/surface/gas sampling* indoors & outdoors)               |  |
| ★ Release station (Air/surface/gas sampling* indoors & outdoors + Release device/setup) |  |
| ○ No station sampling   |  |

Figure 1: Map of Proposed Release and Sampling Locations during Phenomenology Measurements (Subject to Revision). Red stars indicate potential tracer release locations.



**TABLE 4**

**Proposed Platform and MTA Subway Lines for Sampling (Subject to Revision)**

| Station                   | Platform       | Train   | Sampling Activities       | Station                            | Platform       | Train | Activities                 |
|---------------------------|----------------|---------|---------------------------|------------------------------------|----------------|-------|----------------------------|
| 125 St                    | Uptown         | 4,5,6   | Air (PSU & DFU), Surface  | 96 St                              | Downtown       | 1,2,3 | Air (PSU & DFU), Surface   |
| 103 St                    | Uptown         | 6       | Air (PSU & DFU), Surface  | 72 St                              | Downtown       | 1,2,3 | Air (PSU & DFU), Surface   |
| 86 St                     | Uptown Local   | 4,5,6   | Air (PSU & DFU), Surface  | 59 St Columbus Cir.                | Downtown       | 1     | Air (PSU & DFU), Surface   |
| 68 St Hunter College      | Uptown         | 6       | Air (PSU only), Surface   | 50 St                              | Downtown       | 1     | Air (PSU & DFU), Surface   |
| 59 St                     | Uptown Express | 4,5,6   | Air (PSU & DFU), Surface  | Times Square 42 St                 | All            | 1,2,3 | Air (2 PSU & DFU), Surface |
| 51 St                     | Uptown         | 6       | Air (PSU & DFU), Surface  | 34 St Penn Station                 | Express        | 1,2,3 | Air (2 PSU & DFU), Surface |
| Grand Central 42 St       | All            | 4,5,6   | Air (2 PSU, DFU), Surface | 28 St                              | Uptown         | 1     | Air (PSU & DFU), Surface   |
| 33 St                     | Uptown         | 6       | Air (PSU & DFU), Surface  | 23 St                              | Uptown         | 1     | Air (PSU & DFU), Surface   |
| 23 St                     | Downtown       | 6       | Air (PSU & DFU), Surface  | 14 St                              | Uptown         | 1,2,3 | Air (PSU & DFU), Surface   |
| 14 St Union Sq            | Mezzanine      | 4,5,6   | Air (PSU & DFU), Surface  | Houston St                         | Uptown         | 1     | Air (PSU & DFU), Surface   |
| Bleecker St               | Downtown       | 6       | Air (PSU & DFU), Surface  | Franklin St                        | Uptown         | 1     | Air (PSU & DFU), Surface   |
| Brooklyn Bridge City Hall | Downtown       | 4,5,6   | Air (PSU & DFU), Surface  | 96 St                              |                | A,C   | Air (PSU)                  |
| Queensboro Plaza          | Downtown       | N,Q     | Air (DFU)                 | 59 St Columbus Cir.                | Express        | A,C   | Air (PSU)                  |
| Lexington Av / 59 St      |                | N,Q,R   | Air (PSU), Surface        | 50 St                              | Downtown 'E    | C,E   | Air (PSU)                  |
| 57 St / 7 Av              | Uptown         | N,Q,R   | Air (PSU)                 | 42 St Port Authority               | Downtown       | A,C,E | Air (PSU & DFU), Surface   |
| Times Square – 42 St      | Uptown         | N,Q,R   | Air (PSU & DFU), Surface  | 34 St Penn Station                 | Express        | A,C,E | Air (PSU)                  |
| 34 St / Herald Sq         | Uptown         | N,Q,R   | Air (PSU & DFU)           |                                    | Uptown         | A,C,E | Air (PSU)                  |
| 23 St                     | Uptown         | N,R     | Air (DFU)                 | W 4 St Wash Sq                     | Uptown         | A,C,E | Air (PSU)                  |
| 14 St – Union Sq          | Uptown         | N,Q,R   | Air (PSU & DFU)           | Canal St                           | Uptown         | A,C,E | Air (PSU)                  |
| 8 St – NYU                | Uptown         | N,R     | Air (PSU)                 | Court Sq 23 St                     | W to Manhattan | E     | Air (PSU)                  |
| City Hall                 |                | R       | Air (DFU)                 | Lexington Av / 53 <sup>rd</sup> St |                | E     | Air (PSU)                  |
| 47 50 Sts Rockefeller Ctr | Downtown       | B,D,F,M | Air (PSU)                 | 7 Av                               | Downtown       | E     | Air (PSU)                  |
| 34 St Herald Sq           | Uptown         | B,D,F,M | Air (PSU & DFU)           | 3 Av                               |                | L     | Air (DFU)                  |
| W 4 St Wash Sq            | Downtown       | B,D,F,M | Air (PSU)                 | 14 St – Union Sq                   |                | L     | Air (PSU), Surface         |
| Hunters Point Av          | W to Manhattan | 7       | Air (PSU)                 | 8 Av                               |                | L     | Air (DFU)                  |
| Vernon Blvd / Jackson Av  | W to Manhattan | 7       | Air (PSU), Surface        |                                    |                |       |                            |
| Grand Central             |                | 7       | Air (PSU & DFU), Surface  |                                    |                |       |                            |
| Times Sq                  |                | 7       | Air (PSU & DFU), Surface  |                                    |                |       |                            |
| Grand Central             |                | S       | Air (PSU & DFU), Surface  |                                    |                |       |                            |
| Times Sq                  |                | S       | Air (PSU & DFU), Surface  |                                    |                |       |                            |

## 3.2 Air Quality

This section describes the ambient NYC outdoor and subway air quality. An aggregation of air quality studies from several subway stations around the world has been provided for perspective.

### 3.2.1 NYC Metropolitan Outdoor Air Quality

Outdoor air quality in NYC has historically been relatively poor and the city estimates that 6% of the city's annual deaths are attributable to air pollution<sup>21</sup>. The Clean Air Act, last amended in 1990, required the EPA to develop National Ambient Air Quality Standards (NAAQS) for particulate matter with a diameter below 10  $\mu\text{m}$  ( $\text{PM}_{10}$ ) and 2.5  $\mu\text{m}$  ( $\text{PM}_{2.5}$ ). NAAQS define primary standards, which protect the health of "sensitive" populations such as asthmatics, children, and the elderly. In addition, NAAQS defines secondary standards which protect against decreased visibility and damage to animals, crops, vegetation, and buildings. Primary and secondary levels for annual average  $\text{PM}_{2.5}$  have been set at 15  $\mu\text{g}/\text{m}^3$  and 12  $\mu\text{g}/\text{m}^3$ , respectively. A  $\text{PM}_{10}$  24-hr average of 150  $\mu\text{g}/\text{m}^3$  has been defined for primary and secondary concentrations<sup>22</sup>. The city launched an effort in 2007 to achieve the highest outdoor air quality of a major city by the year 2030. The New York City Community Air Survey (NYCCAS) reported annual average  $\text{PM}_{2.5}$  concentrations for the 2010 – 2012 period to be 14  $\mu\text{g}/\text{m}^3$ , a significant reduction from the  $\text{PM}_{2.5}$  annual average of 17  $\mu\text{g}/\text{m}^3$  recorded for 2005 – 2007<sup>23</sup>. Outdoor  $\text{PM}_{10}$  levels have remained steady for the same time period, averaging 60  $\mu\text{g}/\text{m}^3$  for 2005 – 2011<sup>24</sup>. While outdoor  $\text{PM}_{10}$  concentrations for NYC are well below primary and secondary NAAQS, outdoor  $\text{PM}_{2.5}$  concentrations still remain above secondary standards which protect against environmental harm. NYC continues to work towards reducing particulate emissions and meeting national standards.

### 3.2.2 Subway Indoor Air Quality

This section describes inherent particulate matter in air/surface samples (i.e., grime), chemical vapors (summa canister data), and typical cleaning materials found in subways. It should be emphasized that passenger entrances, ventilation shafts, and tunnels allow for a large exchange of air with the outside environment.

#### 3.2.2.1 Airborne and Surface Particulate Samples

Airborne particulate mass concentrations have been measured at several subway systems with a summary of average results in TABLE 5. Airborne particulate mass concentrations were almost always significantly higher inside subway stations than ambient air outside of the stations<sup>25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44</sup>; generally by at least a factor of 4. The exception to this was Guangzhou China where outdoor air pollution was much higher than other cities. Notice that there is a wide range of concentrations depending on the subway

system. Significant mass concentration variations were also measured between stations<sup>45</sup>, seasons<sup>27,31,46,47</sup>, and time of day<sup>44,47</sup> for the same city.

**TABLE 5**  
**Average mass concentration measurements taken in different subway systems**

|                             | Mass Concentration ( $\mu\text{g}/\text{m}^3$ ) |                  |  |                     |                                 |     |  |
|-----------------------------|---|------------------|--|---------------------|---------------------------------|-----|--|
|                             | Outdoor   |                  | Subway   |                     |                                 |     |  |
|                             | PM <sub>2.5</sub>                               | PM <sub>10</sub> | PM <sub>2.5</sub>                                | PM <sub>5</sub>     | PM <sub>10</sub>                | TSP | Description                              |
| Berlin <sup>25</sup>        |   |                  |  |                     | 147                             |     |  |
| Buenos Aires <sup>45</sup>  |   |                  |  |                     |                                 | 211 | Platform                                 |
| Budapest <sup>42</sup>      |   |                  |  |                     | 155                             |     | Platform                                 |
| Boston <sup>48</sup>        |   |                  |  |                     | 205                             |     | Platform (Winter)                        |
| Cairo <sup>37</sup>         |   |                  |  |                     |                                 | 938 |  |
| Guangzhou <sup>49</sup>     | 106   |                  | 44   |                     | 55                              |     |  |
| Helsinki <sup>26</sup>      | 10, 17  |                  | 54<br>21   |                     |                                 |     | Platform (Winter)<br>Subway Car (Winter) |
| Hong Kong <sup>25</sup>     |   |                  | 33   |                     | 44                              |     |  |
| London                      | 23.5 <sup>[27]</sup>                            |                  | 165<br>103 <sup>[27]</sup> , 375 <sup>[50]</sup> |                     | 1,250                           |     | Subway Drivers Cab<br>Platforms (Winter) |
|                             | 34.5 <sup>[27]</sup>                            |                  | 239 <sup>[27]</sup>                              | 801 <sup>[29]</sup> |                                 |     | Platforms (Summer)                       |
| Mexico City <sup>51</sup>   | 71, 38  |                  | 61   |                     |                                 |     |  |
| NYC                         | 13 <sup>[32]</sup>                              |                  | 62 <sup>[32]</sup><br>56 <sup>[33]</sup>         |                     |                                 |     | Platforms & Cars<br>Subway Workers       |
|                             |   |                  |  |                     |                                 |     |  |
| Prague <sup>31</sup>        |   | 74               |  |                     | 103                             |     | Station                                  |
|                             |   |                  |  |                     | 114                             |     | Subway Car                               |
| Rome <sup>40</sup>          |   | 101              |  |                     | 166                             |     | Subway Drivers Cab                       |
|                             |   |                  |  |                     | 407                             |     | Platforms                                |
| Seoul                       |   |                  | 66 <sup>[47]</sup> , 118 <sup>[30]</sup><br>111  |                     | 144<br>126, 137 <sup>[52]</sup> |     | Subway Car<br>Platforms                  |
|                             |   |                  |  |                     |                                 |     |  |
| Stockholm <sup>26</sup>     | 23  |                  | 212  |                     | 386                             |     |  |
| Toronto <sup>53</sup>       | 15  |                  | 159  |                     |                                 |     |  |
| Washington DC <sup>36</sup> |   |                  |  |                     |                                 | 333 |  |

The elevated mass concentration values in the subway are thought to be influenced by passenger activity, floor cleaning, station depth, date of construction, ventilation rate, proportion of frictional to regenerative braking, train frequency, wheel type (rubber vs. steel), and the presence or absence of platform-edge doors and/or air-conditioning in subway cars and stations<sup>33,37</sup>. Analysis has been conducted on collected particulate samples to determine the constituent materials. Iron oxides (e.g.,  $\text{Fe}_3\text{O}_4$ ,  $\text{Fe}_2\text{O}_3$ ) make up the majority of subway particulate mass (e.g., 64 – 71% in London subway<sup>28</sup>). The iron oxides generally create a passivation layer on the surface of iron. Airborne iron is primarily attributed to wear debris from the subway car wheel-rail interface and also braking (contributed 15% total mass<sup>54</sup>). TABLE 6 reports the percentage iron content from a few other cities. A NYC study found that iron content percentage varied depending on the location within the subway system (e.g., 14% for overhaul shop workers, 27% for track workers, 43% for train operators)<sup>33</sup>.

**TABLE 6**  
**Percent iron in subway dust**

| City                              | Fe % |
|-----------------------------------|------|
| <b>Budapest<sup>42</sup></b>      | 42   |
| <b>Buenos Aires<sup>45</sup></b>  | 21   |
| <b>Helsinki<sup>26</sup></b>      | 54   |
| <b>London<sup>28</sup></b>        | 45   |
| <b>NYC<sup>32</sup></b>           | 42   |
| <b>Rome<sup>40</sup></b>          | 10   |
| <b>Seoul<sup>47</sup></b>         | 45   |
| <b>Stockholm<sup>41</sup></b>     | 40   |
| <b>Washington DC<sup>36</sup></b> | 55   |

Other metals found in elevated percentages to the outdoors were chromium (present in steel), manganese (present in steel), copper (present in current collector shoes rubbing against conductor rail), zinc (vehicular traffic), and barium (present in some brakes<sup>25</sup>). The metals are not generally present as elements but as compounds (e.g., oxides, chlorides, sulfides)<sup>36</sup>. Steel, manganese and chromium were found to be more than 100 times higher in the NYC subway system than outdoors<sup>32</sup>. Carbon-rich particles are generally found, attributed to carbon inclusion in steel, oils, and human debris (e.g., clothes fibers, hair, skin)<sup>36,29,25</sup>. Other non-metals found were silica quartz (e.g., 7.2% in Washington DC), attributed to concrete (i.e., construction, degradation)<sup>36</sup>, and chlorides<sup>29,38,47</sup> attributed to the use of road salts for de-icing. A Washington DC study found that subway dust from older WMATA rail lines was not significantly different than dust from newer lines<sup>36</sup>. Also of interest was that power washing only reduced mass concentrations by roughly 10%<sup>34</sup>. The same factors that affect mass concentration levels also affect the composition of subway dust. Therefore, it is important for each facility to conduct analysis on their inherent subway particles.

While some of the underground subway increase in airborne mass concentration is attributable to higher particulate density (i.e., iron), it is also attributed to an increase in total particle counts. Measurements in the Washington DC subway system found that the total particle counts (Smithsonian Station) were at least 2 – 3 times lower in magnitude immediately outside the station for all particle sizes between 0.5 – 9.4  $\mu\text{m}$ <sup>55</sup>. Compared to the outdoors, the subway environment has particles that are heavier (i.e., iron oxides) and in greater numbers. Typical subway station total particle counts (>0.5  $\mu\text{m}$ ) reached 10,000 – 100,000 Particles Per Liter (PPL) of air depending on train operation and time of day<sup>38,46,55</sup>. Fluorescent particles have been reported at <1% of total particle counts<sup>38</sup>. Also of interest is that NYC air-conditioned subway cars reduced particle counts by 75 – 90% compared to the subway station<sup>35</sup>.

With respect to airborne particle sizing, significant increases in coarser particles (i.e., >2  $\mu\text{m}$ ) have been measured for subway dust<sup>28,29</sup>. Measurements in Washington DC, found the largest subway station particle increases (compared to outdoors) in the 1.1 – 3.2  $\mu\text{m}$  particle size range<sup>55</sup>. These coarse particles typically come from grinding activities (wheel-rail interface) and other geological origins (e.g., spores, waste residues)<sup>40</sup>. Many subway particles are angular in shape which is consistent with metal surface abrasion<sup>33</sup>. A Seoul Korea study found that subway dust in the 2.5 – 10  $\mu\text{m}$  range and 1 – 2.5  $\mu\text{m}$  range were made of 77.3% and 70.9% iron, respectively<sup>56</sup>. It is thought that this increase in coarser sized particles is due to the liberation of iron particles at the wheel-rail interface and from braking systems. Park & Ha assert that many smaller particles (< 2  $\mu\text{m}$ ) are from vehicle exhausts and other sources of combustion based on measuring a strong positive correlation between PM<sub>2.5</sub> and CO concentrations<sup>57</sup>.

Bulk dust samples were collected from subway surfaces and analyzed<sup>36</sup>. Particle sizing was conducted with an average normalized distribution of 23.3% (< 2.5  $\mu\text{m}$ ), 27.2% (2.5 – 10  $\mu\text{m}$ ), 42.9% (10-25  $\mu\text{m}$ ), and 6.5% (>25  $\mu\text{m}$ ). A shift to larger particles is seen in the deposited particles. The primary constituent material (40%) was iron.

A recent NYC subway system sampling campaign was completed that examined the types of microorganisms found within stations<sup>58</sup>. The findings suggest a rich and diverse background of microorganisms in the subway environment. Hundreds of organisms classified as bacterial, viral, archaeal, and eukaryotic taxa were found in the subway (with evidence of *E. coli*, *Y. pestis* and *B. anthracis*); however most organisms were considered harmless. There were several *Bacillus* species found within the subways, with the most abundant being *B. cereus* (causes foodborne illness).

#### 3.2.2.2 Vapor Samples

Summa canisters were used to collect vapor backgrounds from an operational MBTA subway station (Park Street Red Line Platform) during revenue hours and the results are shown in TABLE 7. Notice that ethanol is found in the highest concentration; with acetone, isopropyl

alcohol, toluene, and chlorodifluoromethane also found in smaller percentages. It is thought that many of these vapors are caused by human traffic and activities: colognes/perfumes (ethanol, isopropyl alcohol), shampoos (ethanol), suntan lotion (ethanol, acetone), shoe polish (acetone), leather dressings (acetone, toluene), food additives (acetone), food packaging (acetone), cosmetics (ethanol, acetone), anti-acne preparations (ethanol, isopropyl alcohol), body lotions/creams (ethanol, isopropyl alcohol), printing ink (toluene), and hairspray (ethanol, isopropyl alcohol).

Park & Ha measured CO<sub>2</sub> in the Seoul subway system at an average concentration of 1,775 ppm<sup>57</sup>. Fromme found relatively high concentrations of fluoranthene and pyrene; possibly attributed to tar-based products formerly used to preserve wooden railway ties<sup>59</sup>. As discussed earlier, SF<sub>6</sub> gas is present in the NYC background due to an electric substation in mid-town Manhattan.

**TABLE 7**  
**Summa Canister Results Collected from MBTA Park Street Red Line Station**

| Compound                           | CAS No.     | Concentration (ppbv) |          |                     |                     |
|------------------------------------|-------------|----------------------|----------|---------------------|---------------------|
|                                    |             | 12/15/09<br>6 – 12pm | 12 – 6pm | 6/27/12<br>10 – 6pm | 6/28/12<br>10 – 6pm |
| Ethanol                            | 64-17-5     | 78.9                 | 107      | 105                 | 109                 |
| Acetone                            | 67-64-1     | 12.7                 | 7.71     | 10.4                | 11.6                |
| Isopropyl Alcohol                  | 67-63-0     | 3.75                 | 6.48     | 4.04                | 12.0                |
| Toluene                            | 108-88-3    | 6.71                 | 1.52     | BRL (1.0)           | BRL (1.0)           |
| Methane, chlorodifluoro-           | 75-45-6     | 4.75                 | 4.58     |                     |                     |
| Dichlorodifluoromethane (Freon 12) | 75-71-8     | 0.72                 | 0.73     | BRL (1.0)           | BRL (1.0)           |
| Chloromethane                      | 74-87-3     | 0.67                 | 0.69     | BRL (1.0)           | BRL (1.0)           |
| Benzene, 1-ethyl-2-methyl- (01)    | 000611-14-3 | 9.12                 |          |                     |                     |
| m,p-Xylene                         | 179601-23-1 | BRL (0.5)            | 6.82     | BRL (2.0)           | BRL (2.0)           |
| 1,2,4-Trimethylbenzene             | 95-63-6     | BRL (0.5)            | 6.44     | BRL (1.0)           | BRL (1.0)           |
| 1,3,5-Trimethylbenzene             | 108-67-8    | BRL (0.5)            | 4.9      | BRL (1.0)           | BRL (1.0)           |
| 4-Ethyltoluene                     | 622-96-8    | BRL (0.5)            | 3.01     | BRL (1.0)           | BRL (1.0)           |
| Limonene                           | 138-86-3    |                      | 2.70     |                     |                     |
| Ethylbenzene                       | 100-41-4    | BRL (0.5)            | 2.13     | BRL (1.0)           | BRL (1.0)           |
| Isobutane                          | 75-28-5     |                      | 1.71     |                     | 2.34                |
| o-Xylene                           | 95-47-6     | BRL (0.5)            | 1.55     | BRL (1.0)           | BRL (1.0)           |
| n-Heptane                          | 142-82-5    | BRL (0.5)            | 1.47     | BRL (1.0)           | BRL (1.0)           |
| d-Limonene                         | 5989-27-5   | 1.31                 |          |                     |                     |
| 1-Butanol                          | 71-36-3     | 1.22                 |          |                     |                     |
| Indane                             | 496-11-7    | 1.10                 |          |                     |                     |
| Hexane, 3-methyl-                  | 589-34-4    |                      | 1.19     |                     |                     |
| Hexane                             | 110-54-3    | BRL (0.5)            | 0.73     | 3.18                | BRL (1.0)           |

\*BRL = Below Reporting Limit, Value shown in parenthesis



### 3.2.2.3 Typical Cleaning Materials

A cleaning event can create a substantially different temporary air and surface background. Typically stations are power washed with a high pressure hose on a monthly basis. TABLE 8 is a list of typical cleaning materials and their primary chemical components used by MTA NYCT, MetroNorth Railroad and Boston MBTA. Each system used almost entirely different cleaning materials.

**TABLE 8**

**Typical Subway Cleaning Solutions in NYC MTA, MetroNorth Railroad (GCT) and Boston MBTA**

| City                  | Specific Location                               | Name  | Manufacturer                              | Purpose                              |
|-----------------------|---|---|---|--------------------------------------|
| Boston                | MBTA<br>(General)                               | Neutrabrite                                   | Spectrowax Corporation                    | Hard Surface Cleaner                 |
|                       |   | D-GREASE                                      | Spectrowax Corporation                    | Cleaning grease and oil              |
|                       |   | Ethylene Glycol Butyl Ether                   | Sigma-Aldrich                             | Cleaning Solution                    |
|                       |   | Five Star Glass Cleaner                       | Spectrowax Corporation                    | Wash windows                         |
| MTA NYCT<br>(General) |   | TIDE  | P&G                                       | All Purpose Cleaner / Detergent      |
|                       |   | Power Lemon                                   | Nationwide Chemical Co., Inc.             | Disinfectant / Detergent             |
|                       |   | Elite Professional Bleach                     | James Austin Company                      | Disinfectant / Remove Stains         |
|                       |   | Enviro Neutral Cleaner NU                     | W.W. Grainger                             | Daily Floor & Surface Cleaner        |
|                       |   | Sheen Stainless Steel                         | U.S. Industrial Lubricants / Oil Kraft    | Stainless Steel Cleaner and Polish   |
|                       |   | Window / Stainless Steel Cleaner              | National Chemical Laboratories of Pa, Inc | Wash windows and stainless steel     |
|                       |   | NCL 333 Graffiti Remover                      | National Chemical Laboratories of Pa, Inc | Remove Graffiti / Detergent          |
|                       |   | NCL 430 Strawberry/Citrus Deodorant           | National Chemical Laboratories of Pa, Inc | Sanitize                             |
|                       |   | ACCLAIM                                       | Zep Inc                                   | Anti-bacterial handcleaner           |
|                       |   | Solopol                                       | Evonik Stockhausen, Inc.                  | Hand Cleanser                        |
|                       |   | Cream Cleanser #53                            | Enviro-solutions Limited                  | Bathroom Cleaner                     |
|                       |   | Earthsense #20 Washroom Cleaner               | National Chemical Laboratories of Pa, Inc | Washroom Cleaner                     |
| NYC                   |   | Noxon 7                                       | Reckitt Benckiser                         | Metal Polish                         |
|                       |   | Water Base Stainless Steel Maintainer         | Claire                                    | Stainless steel cleaner              |
|                       |   | Shineline Baseboard Stripper                  | Spartan                                   | Clean baseboard, floor edges, stairs |
|                       |   | Rapid Strip                                   | Supply One                                | Stripping                            |
|                       |   | EarthVital Vitalshine Zinc Free Seal & Finish | CapTree PureTech Solutions                | Floor sealer and finish All          |
|                       |   | EarthVital Easy 2 Clean Peroxide Cleaner      | CapTree PureTech Solutions                | Purpose Cleaner Floor shiner         |
|                       | MetroNorth Railroad (Grand<br>Central Terminal) | Super Spraybuff                               | Spartan                                   | Cleanser Hand                        |
|                       |   | Ajax Oxygen Bleach                            | Colgate-Palmolive Company                 | Washing                              |
|                       |   | Hand Soap                                     | Unknown                                   |                                      |
|                       |   | 112 Orange                                    | Unknown                                   |                                      |
|                       |   | 446   | Unknown                                   |                                      |
|                       |   | Hard as Nails                                 | 151 Products Ltd                          | Adhesive                             |
|                       |   | Rapid Stripper                                | Viking Criterion                          | Stripping                            |
|                       |   | Concur  | The Fuller Brush Company                  | Floor Cleaner                        |
|                       |   | Super Mist Odor Counteractant                 | Aireactor                                 | Odor Remover                         |
|                       |   | Vandalism Mark Remover                        | Edmer                                     | Remove Graffiti                      |
|                       |   | Delta Ultra                                   | Pollet                                    | Cleaner / Degreaser                  |

## **Section 4. Environmental Alternatives of Implementing the Alternative Actions**

Information and evaluation data on the different particulate and gas materials gathered from regulatory agencies and published documents are reviewed in this section to address the potential direct or indirect effects on health, safety, and the environment due to implementation of each alternative action.

### ***4.1 Human Health and Safety Effects***

This section will discuss all human health and safety effects related to the release of gas and particulate tracers during the planned testing in the MTA NYCT subway stations. Passenger contact with all particulate and gas alternatives will occur. Contact may include inhalation, ingestion, and dermal contact. Additional potential for contact may occur following testing due to the potential for re-aerosolization of the particulate material due to air movement within the subway station. Ridership during rush hours is expected to be largely comprised of healthy working adults, but young, aged or immune-deficient or immune-compromised riders are also expected to be present during testing. A discussion of the anticipated upper bound of test material exposure will first be discussed. The individual environmental consequences of each individual gas and particulate alternative will then be discussed within their individual health related studies and the planned population exposure.

#### **4.1.1 Human Health and Safety Effects from Particulate Releases**

As stated earlier, the maximum amount of particulate tracer material released within a station over ten minutes, 8 hours, and 24 hours is 20, 20, and 40 grams, respectively. The majority of released material by weight will be in the respirable particle range of 1 – 10  $\mu\text{m}$ . For all particulate alternatives, a 10 foot radius controlled zone will be established on the platform around the release site with no access for the general public permitted while the release occurs. The material will be directed into the airspace to be rapidly mixed into the station, minimizing exposure of any one individual to tracer materials.

TABLE 9 provides particulate release concentrations near the source from previous Boston and NYC testing. Computer modeling particulate concentration results using the Below Ground Model (BGM) developed by Argonne National Laboratory (ANL) are also presented for comparison. It is anticipated that both particulate alternatives will yield similar station concentrations as shown for the Grand Central platform modeling. Notice that all previous releases and modeling results are 1 – 2 orders of magnitude lower in 8-hour Time Weighted Average (TWA) mass concentration than the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) and OSHA permissible exposure limits. It should be noted that there will be a cumulative dosage effect for riders that transit the affected subway stations daily. However, the entire duration of testing will be completed in

approximately one week and all applicable inhalation and ingestion concentrations are well below established guidelines.

A subway passenger that is near the release site for the 15 minutes immediately after dissemination would expect a daily increase in  $PM_{10}$  mass concentration of  $3.8 \mu\text{g}/\text{m}^3$ . An upper bound on the increase in the daily mass concentration (i.e., over 24 hours) directly next to the release site is expected to be  $7.7 \mu\text{g}/\text{m}^3$ . For comparison, the EPA has set a health-based national ambient air quality standard for daily outdoor  $PM_{10}$  content at  $150 \mu\text{g}/\text{m}^3$ . EPA primary standards provide health protection for the public, including the health of “sensitive” populations (e.g., asthmatics, children and elderly). Therefore, even standing next to the release location for 24 hours, the mass concentration increase is only 5.1% of the EPA outdoor guidelines.

Note that much of the material will deposit on surfaces (indoor and outdoor) as well as subway passenger effects (e.g., clothing, hair, skin). Some passengers will transport particulates to other locations (e.g., work, home) via fomite transport (i.e., particulate attachment). The amount of material transported via personal effects will likely be at doses in a similar range to the total amount inhaled. However, this is highly dependent on several factors including particle size, passenger clothing, passenger movement, and humidity. As an example, someone standing on the Grand Central 4,5,6 platform for three hours after a 10 gram release of  $1\text{-}\mu\text{m}$  spherical particles ( $1 \text{ g}/\text{cm}^3$  density) within the station and breathing at 8.5 Liters Per Minute (LPM) could inhale up to  $45 \times 10^6$  total particles ( $< 24 \mu\text{g}$ ) based on modeling estimates. Using the same model (assuming a deposition velocity of  $0.3 \text{ m}/\text{hr}$  averaged over all surfaces), a surface area within Grand Central 4,5,6 platform equal to the approximate total surface area of skin on a human body ( $1.5 \text{ m}^2$ ) would have  $41 \times 10^6$  particles deposited after three hours ( $< 22 \mu\text{g}$ ). Previous aerosol releases at South Station in Boston measured particle deposition velocities much greater on cotton coupons ( $18 \text{ m}/\text{hr}$ ) than stainless steel coupons ( $0.8 \text{ m}/\text{hr}$ ) for polystyrene latex particles (mass median diameter of  $2.7 \mu\text{m}$ ). The majority of this material will remain adhered to surfaces until mechanical agitation and/or wetting; most likely presenting inhalation concentrations much lower than experienced within subway stations.

**TABLE 9**  
**Measured and Expected Mass Concentrations from Subway Particulate Measurements**

|                       | Particle                  | Release Size     | Release Location  | Details                            | PM <sub>10</sub> , Mass Concentration (mg/m <sup>3</sup> ) |       |       |        |
|-----------------------|---------------------------|------------------|-------------------|------------------------------------|--|-------|-------|--------|
|                       |                           |                  |                   |                                    | 15-min   | 1-hr  | 3-hr  | 8-hr   |
| Previous Tracer Tests | <i>B. subtilis</i> mix1   | 18.7 g (burst)   | Boston subway     | Non-revenue (no train)             | 1.25   | 0.39  | 0.13  | 0.05   |
|                       | <i>B. subtilis</i> mix1   | 42 g (burst)     | Boston subway     | Non-revenue (1 train arrival)      | 0.64   | 0.24  | 0.08  | 0.03   |
|                       | Silica mix2               | 146 g (16 g/min) | NYC subway        | Non-revenue (1 train arrival)      | 0.20   | 0.19  | 0.06  | 0.02   |
|                       | Silica mix2               | 65 g (7.2 g/min) | Boston subway     | Non-operational (no train)         | 0.62   | 0.28  | 0.12  | 0.04   |
|                       | Silica mix2               | 55 g (5 g/min)   | Boston subway     | Non-operational (no train)         | 0.65   | 0.24  | 0.10  | 0.04   |
|                       | Urea/OB3                  | 30 g (1.5 g/min) | Boston subway     | Revenue hours                      | 0.70   | 0.44  | 0.20  | 0.08   |
|                       | Pure OB4                  | 30 g (1.5 g/min) | Boston subway     | Revenue hours                      | 0.70   | 0.44  | 0.20  | 0.08   |
|                       | PSL microspheres5         | 1 g (0.05 g/min) | Boston subway     | Revenue hours                      | 0.07   | 0.035 | 0.012 | 0.0045 |
| Modeling              |                           |                  | NYC Grand Central | Next to Release                    | 0.36   | 0.09  | 0.03  | 0.01   |
|                       | DNA-Tagged Carrier        | 20 g (2 g/min)   |                   | Next Station (33 <sup>rd</sup> St) | 0.12   | 0.03  | 0.01  | 0.004  |
| Limits                | OSHA Nuisance Dust PEL    |                  |                   |                                    |  |       |       | 5      |
|                       | ACGIH Nuisance Dust TLV   |                  |                   |                                    |  |       |       | 3      |
|                       | OSHA Amorphous Silica PEL |                  |                   |                                    |  |       |       | 0.8    |

#### 4.1.1.1 Human Health and Safety Effects from Particulate Alternative P1

The first particulate alternative (P1) is to aerosolize DNA oligonucleotides (oligos) encapsulated in maltodextrin particles (referred to as “DNATrax”) and tagged with an Optical Brightener (OB). DNATrax (i.e., DNA oligos encapsulated inside maltodextrin) was developed by Lawrence Livermore National Laboratory (LLNL) for food labeling and has been classified by the Food & Drug Administration (FDA) as Generally Recognized As Safe (GRAS). DNATrax is listed as a nuisance dust on its SDS (provided in Appendix A). DNATrax-OB, which includes encapsulation of both CI Fluorescent Brightener 220 and DNA oligos inside maltodextrin, is proposed as particulate alternative P1 for the described phenomenology tests. The fluorescent tag has been added to make tracer discrimination easier for real-time biological trigger sensors utilizing fluorescence techniques. Safety information for DNATrax-OB components is summarized below.

Maltodextrin is a polysaccharide produced from starch that is often used as a food additive and has FDA Generally Recognized as Safe (GRAS) approval for ingestion. The maltodextrin SDS (provided in Appendix A) lists the OSHA PEL as 5 mg/m<sup>3</sup> (respirable fraction)<sup>60</sup>. Maltodextrin is characterized as a nuisance dust and is not known to have adverse effects on the lungs<sup>60</sup>.

DNA sequences will be chosen from the thermophilic bacterium *Thermotoga maritima* (*T. maritima*) that are non-coding (i.e., do not produce a protein) and dissimilar from DNA sequences of other common biological aerosol microorganisms. The oligos are inert and non-living. Furthermore, environmental DNA (eDNA) is already ubiquitous as byproducts (e.g., skin, hair, urine) from all organisms; therefore there is no additional impact or burden placed on the environment from use of the material. To further verify specificity of each candidate DNA signature, a final computational screening utilizing TaqSim PCR simulation program will verify that no cross-reactions are identified when the signatures are compared against all sequences in genbank, including eukaryotic sequences.

The report of the Ecological and Toxicological Association of Dyes and Organic Pigments Manufacturers (ETAD) submitted to the U.S. EPA High Production Volume (HPV) Chemicals Challenge Program<sup>61</sup>, and accepted by the EPA<sup>62</sup>, summarizes the results of published toxicology studies on CI Fluorescent Brightener 220 and related optical brighteners. According to the studies summarized in the report, these materials are generally not irritating to skin and eyes; toxicity studies in male and female Wistar rats showed that oral doses up to 15,000 mg per kg body weight (the highest level tested) resulted in no fatalities<sup>63,64</sup>. Toxicity studies of a related brightener (CI Fluorescent Brightener 263, CAS No. 67786-25-8) reported no deaths and no signs of toxicity in male and female Wistar rats, male NMRI mice, female New Zealand white rabbits, and female beagle dogs orally administered 2500, 1000, 1000 and 500 mg/kg (respectively)<sup>65</sup>. In inhalation toxicity studies, Wistar rats were exposed for 4 hours to 163, 375, 1,225 and 1,895 mg/m<sup>3</sup> of CI Fluorescent Brightener 28/113 (CAS No. 4404-43-7) (the latter being the maximum attainable concentration)<sup>66</sup>. No mortalities occurred in any group. At doses of 1,225 and 1,895 mg/m<sup>3</sup>, a transient reduction of the general condition of the rats was

observed for 4 – 6 hours. No further clinical symptoms were observed and at the end of the 14 day observation period no findings were noted in pathological examinations. In a similar study<sup>67</sup>, rats exposed to 2,900 mg/m<sup>3</sup> of CAS No. 13863-31-5 for 4 hours did not result in mortality of any of the 10 animals tested. Animals appeared healthy during the 14 days following exposure and had normal weight gains.

A review of toxicity studies for three optical brighteners, including CI Fluorescent Brightener 220, carried out by the German Institute for Consumer Health Protection and Veterinary Medicine<sup>68</sup> also concluded that they pose no risk to consumers. The SDS for CI Fluorescent Brightener is 220 is provided in Appendix A.

The DNATrax-OB particles will have a mass median aerodynamic diameter (MMAD) between 1 – 10 µm, which is considered respirable. The DNATrax-OB particles (including the primary component maltodextrin) are not listed explicitly by OSHA; therefore it is assumed classified as “Particulates Not Otherwise Regulated” by OSHA and at a minimum would be required to remain under the designated 8-hour Time Weighted Average (TWA) respirable Permissible Exposure Limit (PEL) of 5 mg/m<sup>3</sup>. The American Conference of Governmental Industrial Hygienists (ACGIH) recently established a Threshold Limit Value (TLV) of 3 mg/m<sup>3</sup> (respirable) and 10 mg/m<sup>3</sup> (inhalable, i.e., deposits in the nose, throat and upper respiratory tract) for “particles not otherwise specified (PNOS)”. However, the ACGIH PNOS designation applies only to particles that are insoluble or poorly soluble in water (maltodextrin is soluble in water). To be conservative, the lower ACGIH mass concentration will still be shown as in full compliance. As shown in TABLE 9, the maximum concentrations encountered after particle releases (i.e., next to release) are 500 and 300 times lower than the established limits by OSHA and ACGIH for particles not otherwise regulated (i.e., inert or nuisance dusts), respectively. Maltodextrin, CI Fluorescent Brightener 220 and the DNA oligos are not anticipated to present a significant risk to human health and safety.

#### 4.1.1.2 Human Health and Safety Effects from Particulate Alternative P2

The second particulate alternative (P2) is to aerosolize P1 or DNA oligos attached to amorphous silica particles. Particulate Alternative P2 will be referred to as DNATrax-OB-Silica. The fluorescent tag has been added to make tracer discrimination easier for real-time biological trigger sensors utilizing fluorescence techniques. Safety information for DNATrax-OB-Silica is summarized below with SDS’s provided in Appendix A.

Amorphous silica (SiO<sub>2</sub>, CAS: 7631-86-9), the primary component in Alternative P2, is used as an anti-caking agent (e.g., dried eggs), filler for the rubber industry, and a carrier for liquid active ingredients in human and animal nutrition. Amorphous silica is found naturally in dust from microscopic marine plant fossil skeletons (i.e., diatomaceous earth). One of the major problems with assessing the health effects from amorphous silica is contamination from crystalline silica<sup>69</sup>. Crystalline silica can cause several negative human health effects such as silicosis, tuberculosis, chronic bronchitis/chronic obstructive pulmonary disease (COPD) and

lung cancer. However, all amorphous silica that is proposed for use will be synthetically manufactured, avoiding contamination with crystalline silica. No silicosis has been found in the epidemiological studies involving workers with long-term exposure to intentionally manufactured Synthetic Amorphous Silica (SAS)<sup>69</sup>. In addition, long-term animal inhalation experiments exposed to high concentrations of amorphous silica ( $> 10 \text{ mg/m}^3$ ) showed no persistent silicotic nodules (crystalline silica clearly demonstrated this effect)<sup>69</sup>. No adverse changes were observed in Wistar rats<sup>70</sup> exposed to three different types of respirable SAS particles at  $1 \text{ mg/m}^3$  (6-hrs a day for five consecutive days).

Silica gels (minimum silica content 89.5%) are considered GRAS when used as anti-foaming agents<sup>71</sup>. Silicon dioxides are considered GRAS as substances migrating from paper and paperboard products used in food packaging<sup>72</sup>. In 2010, Cabot Corporation submitted a proposed regulation to the U.S. FDA designating the addition of up to 2% SAS in several food categories as Generally Recognized As Safe (GRAS)<sup>73</sup>. The FDA responded that:

“Based on the information provided by Cabot, as well as other information available to the FDA, the agency has no questions at this time regarding Cabot’s conclusion that SAS is GRAS under the intended conditions of use. The agency has not, however, made its own determination regarding the GRAS status of the subject use of SAS.”

In November 2014, the Evonik Corporation also determined SAS to be GRAS and submitted a new proposed regulation to the FDA for consideration<sup>74</sup>. It is currently under review by the U.S. FDA. The amorphous silica SDS lists the OSHA PEL as  $0.8 \text{ mg/m}^3$  (respirable fraction)<sup>75</sup>.

Maltodextrin is a polysaccharide produced from starch that is often used as a food additive and has FDA Generally Recognized as Safe (GRAS) approval for ingestion. The maltodextrin SDS (provided in Appendix A) lists the OSHA PEL as  $5 \text{ mg/m}^3$  (respirable fraction)<sup>76</sup>. Maltodextrin is characterized as a nuisance dust and is not known to have adverse effects on the lungs<sup>60</sup>.

DNA sequences will be chosen that are non-coding (i.e., do not produce a protein) and dissimilar from DNA sequences found in other common biological aerosol microorganisms. The oligos will be inert and are non-living. Furthermore, environmental DNA (eDNA) is already ubiquitous as byproducts (e.g., skin, hair, urine) from all organisms; therefore there is no additional impact or burden placed on the environment from use of the material. To further verify specificity of each candidate DNA signature, a final computational screening utilizing TaqSim PCR simulation program will verify that no cross-reactions are identified when the signatures are compared against all sequences in genbank, including eukaryotic sequences.

As described earlier, Fluorescent Optical Brightener 220 is used safely in several U.S. commercially available products. Amorphous silica, CI Fluorescent Brightener 220 and the attached DNA oligos/maltodextrin do not present a significant risk to the environment or human health.



Amorphous silica is regulated by OSHA and would be required to remain under the designated 8-hour Time Weighted Average (TWA) respirable PEL of 0.8 mg/m<sup>3</sup>. The DNATrax-OB-Silica particles will have a mass median aerodynamic diameter (MMAD) between 1 – 10 µm, which is considered respirable. As shown in TABLE 9, the maximum concentrations encountered after particle releases would be well below the established OSHA limit. Amorphous silica, CI Fluorescent Brightener 220 and the DNA oligos are not anticipated to present a significant risk to human health and safety.

#### **4.1.2 Human Health and Safety Effects from Gas Releases**

As stated earlier, the maximum amount of gas to be released within a station over ten minutes, 8 hours, and 24 hours are 1, 1, and 2 kilograms, respectively for SF<sub>6</sub> and 0.5, 0.5, and 1.0 kilograms for PFTs. TABLE 10 lists gas concentrations measured near the point of release during previous Boston subway tests adjusted to the release amounts in TABLE 3. The OSHA PEL and ACGIH TLV for SF<sub>6</sub> and the Acceptable Air Concentration (AAC) for PFTs are also indicated.

**TABLE 10**  
**Maximum Observed Tracer Concentrations\* during Boston MBTA Subway Studies**

| Tracer Gas                       | Average ppmv* |      |      |        |
|----------------------------------|---------------|------|------|--------|
|                                  | 15-min        | 1-hr | 3-hr | 8-hr** |
| SF <sub>6</sub>                  | 7.6           | 2.8  | 1.2  | 0.4    |
| <i>OSHA PEL, ACGIH TLV Limit</i> | –             | –    | –    | 1,000  |
| PDCB                             | 5.0           | 3.0  | 1.0  | 0.38   |
| PMCH                             | 3.0           | 1.6  | 0.7  | 0.25   |
| mPDCH                            | 1.5           | 0.8  | 0.3  | 0.11   |
| <i>AAC Limit</i>                 | 9.0           | –    | –    | 3.0    |

\*Adjusted for the release amounts in TABLE 3

\*\*Based on 3-hour exposure measurements

Based on the maximum concentrations observed during the Boston subway tests the expected concentrations in NYC would be well within the established limits for these release amounts.

The PFTs released in the MTA NYCT subway system during the S-SAFE Program were not entirely the same as those in TABLE 3 but nevertheless provide a useful indicator of the likely maximum PFT concentrations immediately at the release point. TABLE 11 presents the average 10-minute PFT concentrations observed at the release locations in the MTA NYCT subway *while the tracer releases were in progress* during S-SAFE, adjusted to the release amounts in TABLE 3. Other PFTs, including PDCB, were released aboveground during the S-SAFE Program, but are not included here.

**TABLE 11**  
**Observed Tracer Concentrations\* during MTA NYCT Subway Studies**

| Tracer Gas       | Average ppmv* |            |            |
|------------------|---------------|------------|------------|
|                  | 10-min        | 30-min     | 8-hr       |
| PMCH             | 7.5           | ---        | 0.012      |
| ptPDCH**         | 11.5          | ---        | 0.006      |
| iPPCH            | 7.9           | ---        | 0.022      |
| PTCH             | 3.9           | ---        | 0.01       |
| BGM Modeling     | 0.84          | 0.34       | 0.025      |
| <i>AAC Limit</i> | <i>9.0</i>    | <i>---</i> | <i>3.0</i> |

\*Adjusted for the release amounts in TABLE 3

\*\*ptPDCH is an isomer of mPDCH

TABLE 11 also includes the 10-min, 30-min, and 8-hr average PFT concentrations predicted by the ANL Below Ground Model (BGM) for the 50-ft section of the subway platform containing the release location. The rapid dilution of material with distance from the release point causes the 10-min average from the model of this 50-ft section to be about ten times less than the 10-min averages measured directly at the point of release. The 8-hr model prediction is comparable to the measured value for iPPCH, which was released in the same subway station assumed in the model calculation.

#### 4.1.2.1 Human Health and Safety Effects from Gas Alternative G1

Gas alternative G1 involves the release of SF<sub>6</sub> alone. It is evident from TABLE 10 that the maximum concentrations likely to be encountered in this study are far below the established limits. In addition, SF<sub>6</sub> has been released in subways in Washington, DC and Boston many times without adverse effects.

#### 4.1.2.2 Human Health and Safety Effects from Gas Alternative G2

Gas alternative G2 involves the release of three PFTs in addition to SF<sub>6</sub>. TABLE 10 indicates that, based on the PFT releases in the Boston subway, the expected maximum concentrations would be within the established AAC limits. TABLE 11 shows that the S-SAFE measurements at the PFT release locations in the MTA NYCT subway, after adjusting for the release amounts in TABLE 3, largely confirm this. The exception is the isomer of mPDCH, ptPDCH, which is slightly greater than the AAC 10-min limit. However, this limit may be exceeded for no more

than 30 minutes in one day<sup>18</sup> and may not exceed 15 ppmv. Because the PFT releases will only last 10 minutes, rapid dilution of the tracers by the subway trains will ensure that this limit will not be exceeded, as the model calculation presented in TABLE 11 suggests. Also, the measured 10-min concentrations in TABLE 11 were at the point of release; as described earlier, the release locations will be cordoned off to keep subway patrons at a distance. In addition, subway patrons are unlikely to be in the vicinity of the release for more than a few minutes while they wait for a train.

PFTs have previously been released in subways in NYC, Washington DC, and Boston without adverse effects. The SDS for each PFT proposed for release is provided in Appendix A.

## **4.2 Environmental Effects on Wildlife**

The potential for exposure of terrestrial wildlife to the particulate and gas materials due to movement of the material with the air vented from the station, or with the train as it travels out of the station and above ground was evaluated. DNATrax-OB will not impact the surrounding environment. The primary component, maltodextrin, is already used extensively in several food and drink products (e.g., beer, protein shakes, and sweeteners such as Splenda). The DNA oligos are safe and are comprised of the same four nucleotides as all other DNA (uniqueness comes from differences in sequence)<sup>77</sup>. The particular sequence will be made to look distinctly different from known pathogens that are searched for within the DHS BioWatch air sampling program. The fluorescent brightener (CI fluorescent brightener 220) is used in several products found commonly in Manhattan (paper, clothing). It has been tested extensively on animals and has presented little to no risk. The OB is soluble in water and is removed by >75% to >95% through adsorption from sewage with direct photolysis a second elimination process (half-life for the OB on surface water is 3.9 – 5.2 hours)<sup>78</sup>. OB acute toxicity levels are known for fish (*Brachydanio rerio*; 96 h-LC<sub>0</sub> > 1,000 mg/L), daphnia (*Daphnia magna*; 48 h-EC<sub>0</sub> ≥ 113 mg/L), and algae (*Scenedesmus subspicatus*; 96 h-EC<sub>50</sub> > 1,000 mg/L). There will be less than 68 g of OB released over the duration of all proposed tests (approximately one week). Toxicity levels for daphnia (the lowest toxicity level) would only be exceeded if the entire OB supply were deposited in a water reservoir containing 601.8 liters (~ 4 bathtubs of water).

DNATrax-OB-Silica will not impact the surrounding environment. The primary component, amorphous silica, is found naturally in marine plant fossil skeletons and is already used extensively in several products commonly found in Manhattan such as toothpaste, anti-caking agents (e.g., dried eggs) and carriers for liquid active ingredients in human and animal nutrition. DNA and OB has been discussed earlier and will present no additional risk to the environment.

Likewise, release of both SF<sub>6</sub> and PFTs in the amounts detailed earlier will have no discernable impacts on wildlife due to the low concentrations that will be observed and the absence of toxic effects from the gas tracers.

With respect to the gas alternatives, SF<sub>6</sub> is currently present at appreciable levels within the NYC environment from electric power substations. There have been no reported adverse effects. The three proposed perfluorocarbons are not known to cause adverse health effects, even at high concentrations as discussed earlier.

### ***4.3 Global Warming Potential***

SF<sub>6</sub> and PFTs are considered potent greenhouse gases in comparison to carbon dioxide. However, their contributions to global warming are small compared to the primary anthropogenic sources: carbon dioxide, methane, and nitrogen oxide due to the very low amount of SF<sub>6</sub> and PFTs in the atmosphere<sup>79</sup>. The relative contribution to global warming potential from the tracer gases described in this document is often measured in terms of Greenhouse Warming Potential (GWP). This is defined as the time-integrated radiative forcing of a tracer substance relative to the same mass of reference gas (taken here as CO<sub>2</sub>)<sup>80</sup>. The GWP of SF<sub>6</sub> is 23,600<sup>5</sup>. The GWP of the particular PFTs used in this study are not published, but can be conservatively estimated as 10,000 based on the acceptance range of GWP for PFTs as 1,000 – 10,000<sup>19</sup>. Using these GWPs for the tracers, the upper bound is estimated at 193 MTCDE (Metric Tons Carbon Dioxide Equivalent) or 424,600 lbs of CO<sub>2</sub> equivalent.

The amount of PFTs and SF<sub>6</sub> that will be released in this study (SF<sub>6</sub>: 5 kg, PFTs: 7.5 kg) is a minuscule fraction of the industrial emissions of these gases. The tracers have a GWP of only 0.0005% (1 out of 200,000) of the total PFTs and SF<sub>6</sub> released in the U.S. in 2008<sup>5</sup> and only 0.008% of the GWP from fugitive SF<sub>6</sub> emissions in NYC in 2008 alone.

### ***4.4 Environmental Compliance***

Equipment used to generate releases and collect samples will be returned to the laboratory, cleaned and evaluated for reuse. All sampling waste generated during sample collection (e.g., gloves, filters) will be disposed of properly. None of the equipment or personnel will generate loud noises that will disturb the environment. None of the materials brought to the stations will generate Resource Conservation and Recovery Act (RCRA) regulated hazardous waste. The wastes generated will not significantly differ between any of the Alternatives.

### ***4.5 Environmental Justice***

In accordance with Executive Order 12898,<sup>81</sup> federal agencies should determine whether their activities have a “disproportionately high and adverse human health or environmental effects on minority populations and low-income populations”.

All releases and the majority of sampling will take place in Manhattan. There are 1,585,873 people living in Manhattan, 48% non-Hispanic White, 25.4% Hispanic, 12.9% non-Hispanic

black, 11.2% non-Hispanic Asian, and 0.1% non-Hispanic American Indian<sup>82</sup>. Manhattan has the second highest percentage of non-Hispanic Whites of the five NYC boroughs. Approximately 21% of Manhattan households are below the federal poverty level.<sup>83</sup> However, the top 5 percent of Manhattan households earned \$864,394, which is 88 times more than the poorest 20% of residents. This is the biggest dollar income gap of any county in the U.S. Therefore, the chosen location has a diverse set of races and incomes.

With respect to health effects from particulate simulants, the small quantity of material proposed for release in the subway tests will result in upper bound concentrations (i.e., next to release site) that are over an order of magnitude lower than the established limits by OSHA and ACGIH, respectively (See Section 4.1.1 Human Health and Safety Effects from Particulate Releases). A subway passenger that is near the release site for the 15 minutes immediately after dissemination would expect a daily increase in PM<sub>10</sub> mass concentration of 3.8 µg/m<sup>3</sup>. An upper bound on the increase in the daily mass concentration (i.e., over 24 hours) directly next to the release site is expected to be 7.7 µg/m<sup>3</sup>. For comparison, the EPA has set a health-based national ambient air quality standard for daily outdoor PM<sub>10</sub> content at 150 µg/m<sup>3</sup>. EPA primary standards provide health protection for the public, including the health of “sensitive” populations (e.g., asthmatics, children and elderly). Therefore, even standing next to the release location for 24 hours, the mass concentration increase is expected to be only 5.1% of the EPA recommended outdoor guidelines.

With respect to health effects from gas simulants, the small quantity of SF<sub>6</sub> material proposed for release in the subway tests will result in upper bound concentrations (i.e., next to release site) that are over three orders of magnitude lower than the established limits by OSHA and ACGIH, respectively (See Section 4.1.2 Human Health and Safety Effects from Gas Releases). Because perfluorocarbons are not known to cause adverse health effects, even at high concentrations, no OSHA PEL, ACGIH TLV, or Acute Exposure Guideline Level (AEGL) have been established. For S-SAFE, an 8-hr Acceptable Air Concentration (AAC) limit of 3 ppm was established<sup>84</sup> for the PFTs. This threshold was based on the known toxicity profile of cyclohexane, which is an industrial solvent, not an inert perfluorocarbon compound. Even at this conservative estimate, upper bound PFT concentrations (i.e., next to release site) will be approximately an order of magnitude lower than the 8-hr AAC threshold recommended.

There is no evidence that low income or minority populations would receive a higher exposure to the particulate or gas material than any other group. Furthermore, even if these groups have a higher prevalence of “sensitive” populations (e.g., asthmatics), maintaining recommended EPA outdoor PM<sub>10</sub> mass concentration levels and being well below gas thresholds (i.e., OSHA PELs, ACGIH TLVs, recommended AAC) illustrates that these alternatives would not disproportionately impact minority or low-income communities.

## ***4.6 Historic Properties***

Pursuant to Section 106 of the National Historic Preservation Act of 1966 (NHPA) and its implementing regulations at 36 C.F.R. Part 800, consideration was given to the impact of the tests on any historic properties. The three stations where releases are planned (i.e., Times Square, Grand Central, Penn Station), as well as many stations where sampling is planned, are listed on the National Register of Historic Places. However, as discussed earlier in the document, there are no permanent changes that will occur as part of the project and temporary changes proposed are extremely minor. The project has no potential to effect historic properties as all equipment deployed is portable, has a small footprint, and requires no physical permanent changes to the deployed location. Operation and access to these stations will remain unimpeded. Furthermore, the New York State Historic Preservation Office (NYSHPO) has been contacted regarding the project and determined that review was not necessary.

## **Section 5. Conclusion and Identification of the Proposed Action**

There were three particulate (P1, P2 and P3) and three gas (G1, G2 and G3) alternatives considered for the proposed phenomenology experiments. An aerosol release of DNATrax-OB (P1) and/or DNATrax-Silica-OB (P2) would provide highly sensitive and specific measurements, allowing for the assessment of subway dispersion models. These particulates will also allow for an estimation of the amount of material reaerosolized, deposited on surfaces and passengers, as well as mechanically filtered from train HVAC systems. Therefore, the use of DNATrax-OB and/or DNATrax-OB-Silica is recommended for the current phenomenology experiments. Characterization work (e.g., limit of detection measurements, sizing capabilities, reaerosolization chamber tests) is ongoing to determine whether DNATrax-OB and/or DNATrax-OB-Silica will be released. Both alternatives may ultimately be used to create different particle size distributions; however the total amount of particulate material released will not exceed what was documented in TABLE 2. The no particulate alternative will not help to validate current particulate models and therefore does not meet the needs of the development effort and test.

The gas tracers allow the measurements from this study to be linked with previous subway studies carried out in NYC, Washington, DC, and Boston that also used these tracers. In addition, gas tracers do not deposit on surfaces and are not removed by mechanical filtration in train car HVAC systems, thereby permitting the effect of these removal processes on the particulate tracers to be more clearly identified.

The three gas tracer alternatives are SF<sub>6</sub> alone, SF<sub>6</sub> in combination with three PFTs, and no gas released, respectively. Substantial fugitive emissions of SF<sub>6</sub> may exist in NYC, which could limit the ability to detect an SF<sub>6</sub> tracer more than a few stations away from the release point. However, even in the presence of significant background levels, the real-time measurement capability afforded by SF<sub>6</sub> would be invaluable for monitoring the concentration levels in stations near the release point, for obtaining high time-resolution data needed to

determine ventilation rates in the subway stations, and to readily discern if general subway air flows are far different than anticipated.

The addition of PFTs would complement the SF<sub>6</sub> measurements by permitting measurements to be obtained at lower concentrations and at greater distances from their point of release because of their extremely low background levels. The PFTs would be released in different locations during the same test but collected with the same samplers thereby enabling multiple tests to be conducted simultaneously for identical conditions with very little additional effort. For these reasons, the combined release of SF<sub>6</sub> and PFTs is recommended.



## **Section 6. Persons and Agencies Contacted**

Dr. Charles Burrus  
MTA/NYC Transit, Department of Security  
Deputy Chief, Technology Applications Unit  
Counter-terrorism/Vulnerability Mitigation Div.  
Chief Administrator, WMD-HazMat Response Team

Mr. Michael Gemelli  
Manager, Environmental Monitoring & Emergency Response  
Ops Director, NYCT WMD Hazmat Response Team  
Department of Security

Mr. Christopher S. Higgins  
Chief, Counter Terrorism / Security Command Center  
MTA NYCT Department of Security

Dr. Michael V. Walter  
Detection Branch Chief & BioWatch Program Manager  
Dept. Homeland Security  
Office of Health Affairs

CAPT Daniel Yereb  
USPHS, Director for BioWatch Field Operations Detection Branch, Health Threats Resilience  
Division  
Department of Homeland Security

Dr. Yair Hazi  
Systems Engineering & Technical Assistance Contractor  
BioWatch Jurisdictional Coordinator, New York City  
New York City BioWatch Program Office  
Office of Health Affairs, Department of Homeland Security

Dr. Danimargot Zavasky  
Medical Director, Counterterrorism Bureau  
New York City Police Department

Dr. Joel Ackelsberg  
NYC Department of Health and Mental Hygiene  
Bureau of Communicable Diseases

Dr. Donald Bansleben  
Program Manager  
Chemical and Biological Defense Division  
Department of Homeland Security

Dr. Angela Ervin  
Program Manager  
Chemical and Biological Defense Division  
Department of Homeland Security

Dr. John Fischer  
Division Director  
Chemical and Biological Defense Division  
Department of Homeland Security

Dr. Christina Rudzinski  
Assistant Group Leader, Chemical and Biological Defense Systems  
Massachusetts Institute of Technology Lincoln Laboratory

Dr. Benjamin L. Ervin  
Technical Staff, Chemical and Biological Defense Systems  
Massachusetts Institute of Technology Lincoln Laboratory

## **Appendix A: Safety Data Sheets**



# SAFETY DATA SHEET

Issuing Date 18-Sep-2014

Revision Date 18-Sep-2014

Revision Number 0

## 1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

### GHS product identifier

**Product Name** DNA Tagged Reagents for Aerosol Experiments

### Other means of identification

**Synonyms** DNATrax

### Recommended use of the chemical and restrictions on use

**Recommended Use** No information available

**Uses advised against** No information available

### Supplier's details

#### **Supplier Address**

Lawrence Livermore National Laboratory  
7000 East Ave.  
Livermore, CA 94550  
TEL: 925-422-1100

### Emergency telephone number

**Emergency Telephone Number** 925-422-1100

## 2. HAZARDS IDENTIFICATION

### Classification

This chemical is not considered hazardous according to the OSHA Hazard Communication Standard 2012 (29 CFR 1910.1200).

### GHS Label elements, including precautionary statements

#### **Emergency Overview**

The product contains no substances which at their given concentration are considered to be hazardous to health  
**Appearance** White **Physical State** Solid/Powder. **Odor** Slightly sweet

### **Precautionary Statements**

#### **Prevention**

- None

#### **General Advice**

- None

**Storage**

- None

**Disposal**

- None

**Hazard Not Otherwise Classified (HNOC)**

Not applicable

**Other information**

Dust contact with the eyes can lead to mechanical irritation.

**3. COMPOSITION/INFORMATION ON INGREDIENTS****Synonyms**

DNATrax

| Chemical Name      | CAS-No    | Weight % |
|--------------------|-----------|----------|
| Maltodextrin       | 9050-36-6 | 99.9999  |
| Non-Biological DNA | -         | 0.0001   |

**4. FIRST AID MEASURES****Description of necessary first-aid measures**

|                     |   |
|---------------------|---|
| <b>Eye Contact</b>  | Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.  |
| <b>Skin Contact</b> | Wash skin with soap and water. If skin irritation or rash occurs: Get medical advice/attention.   |
| <b>Inhalation</b>   | IF INHALED: If breathing is difficult, remove to fresh air and keep at rest in a position comfortable for breathing. Get medical attention. |
| <b>Ingestion</b>    | Clean mouth with water and afterwards drink plenty of water. Do NOT induce vomiting. Get medical attention.                                 |

**Most important symptoms/effects, acute and delayed**

**Most Important Symptoms/Effects** None known

**Indication of immediate medical attention and special treatment needed, if necessary**

**Notes to Physician** Treat symptomatically.

**5. FIRE-FIGHTING MEASURES****Suitable Extinguishing Media**

Use extinguishing measures that are appropriate to local circumstances and the surrounding environment.

**Unsuitable Extinguishing Media** No information available.

**Specific Hazards Arising from the Chemical**

No information available.

**Explosion Data**

**Sensitivity to Mechanical Impact**

None.

**Sensitivity to Static Discharge**

None.

**Protective Equipment and Precautions for Firefighters**

As in any fire, wear self-contained breathing apparatus pressure-demand, MSHA/NIOSH (approved or equivalent) and full protective gear.

## 6. ACCIDENTAL RELEASE MEASURES

### Personal precautions, protective equipment and emergency procedures

**Personal Precautions** Ensure adequate ventilation. Avoid contact with eyes. Refer to Section 8 for personal protective equipment.

### Environmental Precautions

**Environmental Precautions** No special environmental precautions required. See Section 12 for additional Ecological Information.

### Methods and materials for containment and cleaning up

**Methods for Containment** Take up mechanically and collect in suitable container for disposal.

**Methods for Cleaning Up** Clean contaminated surface thoroughly.

## 7. HANDLING AND STORAGE

### Precautions for safe handling

**Handling** Handle in accordance with good industrial hygiene and safety practice. Avoid contact with eyes.

### Conditions for safe storage, including any incompatibilities

**Storage** Keep containers tightly closed in a dry, cool and well-ventilated place.

**Incompatible Products** Oxidizing agents.

## 8. EXPOSURE CONTROLS / PERSONAL PROTECTION

### Control parameters

**Exposure Guidelines** This product does not contain any hazardous materials with occupational exposure limits established by the region specific regulatory bodies.

Exposure limits to follow are those for nuisance particulates:  
ACGIH TLV TWA: 10 mg/m<sup>3</sup> of total dust  
OSHA PEL TWA: 15 mg/m<sup>3</sup> of total dust

### Appropriate engineering controls

**Engineering Measures** Showers  
Eyewash stations  
Ventilation systems

### Individual protection measures, such as personal protective equipment

**Eye/Face Protection** None required under normal usage. Risk of contact, wear: Safety glasses with side-shields.

**Skin and Body Protection** None required under normal usage. Risk of contact: Protective gloves. Lightweight protective clothing.

**Respiratory Protection** None required under normal usage. If exposure limits are exceeded or irritation is experienced, NIOSH/MSHA approved respiratory protection should be worn. Respiratory protection must be provided in accordance with current local regulations

**Hygiene Measures** Handle in accordance with good industrial hygiene and safety practice.

## 9. PHYSICAL AND CHEMICAL PROPERTIES

**Information on basic physical and chemical properties**

| <b>Property</b>                        | <b>Values</b>                 | <b>Remarks/ - Method</b> |
|--|-------------------------------|--------------------------|
| Physical State                         | Solid/Powder                  |                          |
| Odor                                   | Slightly sweet                |                          |
| Appearance                             | White                         |                          |
| Odor Threshold                         | No information available      |                          |
| pH                                     | Not applicable                | None known               |
| Melting Point/Range                    | No data available             | None known               |
| Boiling Point/Boiling Range            | Not applicable                | None known               |
| Flash Point                            | Not applicable.               | None known               |
| Evaporation rate                       | No data available             | None known               |
| Flammability (solid, gas)              | No data available             | None known               |
| Flammability limit                     |                               |                          |
| Limits in Air upper flammability       | No data available             |                          |
| lower flammability limit               | No data available             |                          |
| Vapor Pressure                         | No data available             | None known               |
| Vapor Density                          | No data available             | None known               |
| Specific Gravity                       | Not applicable                | None known               |
| Water Solubility                       | Soluble in cold and hot water | None known               |
| Solubility in other solvents           | No data available             | None known               |
| Partition coefficient: n-octanol/water | Not applicable                | None known               |
| Autoignition Temperature               | No data available             | None known               |
| Decomposition Temperature              | No data available             | None known               |
| Viscosity                              | Not applicable                | None known               |
| Flammable Properties                   | Not flammable                 |                          |
| Explosive Properties                   | No data available             |                          |
| Oxidizing Properties                   | No data available             |                          |
| <u>Other information</u>               |                               |                          |
| VOC Content (%)                        | Not applicable.               |                          |

**10. STABILITY AND REACTIVITY****Reactivity**

Not reactive under normal conditions.

**Chemical stability**

Stable under recommended storage conditions.

**Possibility of hazardous reactions**

None under normal processing.

**Hazardous Polymerization**

Hazardous polymerization does not occur.

**Conditions to avoid**

Ignitions sources - heat, sparks and open flames.

**Incompatible materials**

Oxidizing agents.

**Hazardous decomposition products**

None known.

## 11. TOXICOLOGICAL INFORMATION

### Information on likely routes of exposure

#### Product Information

**Inhalation**

Inhalation of dust in high concentration may cause irritation of respiratory system.

**Eye Contact**

Dust contact with the eyes can lead to mechanical irritation.

**Skin Contact**

No known hazard in contact with skin.

**Ingestion**

Low order of toxicity based on components. No known hazard by swallowing. May cause gastrointestinal discomfort if consumed in large amounts.

### Symptoms related to the physical, chemical and toxicological characteristics

**Symptoms** None known

### Delayed and immediate effects and also chronic effects from short and long term exposure

**Sensitization**

No information available.

**Mutagenic Effects**

No information available.

**Carcinogenicity**

Contains no ingredients above reportable quantities listed as a carcinogen.

**Reproductive Toxicity**

No information available.

**STOT - single exposure**

No information available.

**STOT - repeated exposure**

No information available.

**Aspiration Hazard**

No information available.

### Numerical measures of toxicity - Product

**LD50 Oral** >5000 mg/kg; (ATE)

## 12. ECOLOGICAL INFORMATION

### Ecotoxicity

Contains no substances known to be hazardous to the environment or not degradable in waste water treatment plants.

**Persistence and Degradability** No information available.

**Bioaccumulation** No information available.

### Other Adverse Effects

No information available.

## 13. DISPOSAL CONSIDERATIONS

### **Waste Disposal Methods**

This material, as supplied, is not a hazardous waste according to Federal regulations (40 CFR 261). This material could become a hazardous waste if it is mixed with or otherwise comes in contact with a hazardous waste, if chemical additions are made to this material, or if the material is processed or otherwise altered. Consult 40 CFR 261 to determine whether the altered material is a hazardous waste. Consult the appropriate state, regional, or local regulations for additional requirements.

**Contaminated Packaging** Do not re-use empty containers.

## 14. TRANSPORT INFORMATION

**DOT** Not regulated

**IATA** Not regulated.



|                 |                |
|-----------------|----------------|
| <b>IMDG/IMO</b> | Not regulated. |
|-----------------|----------------|

## 15. REGULATORY INFORMATION

### International Inventories

|             |        |
|-------------|--------|
| <b>TSCA</b> | Exempt |
| <b>DSL</b>  | Exempt |

### Legend

**TSCA** - United States Toxic Substances Control Act Section 8(b) Inventory

**DSL/NDL** - Canadian Domestic Substances List/Non-Domestic Substances List

### U.S. Federal Regulations

Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA). This product does not contain any chemicals which are subject to the reporting requirements of the Act and Title 40 of the Code of Federal Regulations, Part 372.

### SARA 311/312 Hazard Categories

|  |    |
|--|----|
| <b>Acute Health Hazard</b>               | No |
| <b>Chronic Health Hazard</b>             | No |
| <b>Fire Hazard</b>                       | No |
| <b>Sudden Release of Pressure Hazard</b> | No |
| <b>Reactive Hazard</b>                   | No |

### Clean Water Act

This product does not contain any substances regulated as pollutants pursuant to the Clean Water Act (40 CFR 122.21 and 40 CFR 122.42).

### CERCLA

This material, as supplied, does not contain any substances regulated as hazardous substances under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) (40 CFR 302) or the Superfund Amendments and Reauthorization Act (SARA) (40 CFR 355). There may be specific reporting requirements at the local, regional, or state level pertaining to releases of this material.

### U.S. State Regulations

#### California Proposition 65

This product does not contain any Proposition 65 chemicals.

### U.S. State Right-to-Know Regulations

This product does not contain any substances regulated by state right-to-know regulations.

### U.S. EPA Label Information

**EPA Pesticide Registration Number** Not applicable

## 16. OTHER INFORMATION

|             |                        |                       |                          |  |
|-------------|------------------------|-----------------------|--------------------------|--|
| <b>NFPA</b> | <b>Health Hazard</b> 1 | <b>Flammability</b> 0 | <b>Instability</b> 0     | <b>Physical and Chemical Hazards -</b> |
| <b>HMIS</b> | <b>Health Hazard</b> 1 | <b>Flammability</b> 0 | <b>Physical Hazard</b> 0 | <b>Personal Protection</b> X           |

|                      |  |
|----------------------|--|
| <b>Prepared By</b>   | Product Stewardship<br>23 British American Blvd.<br>Latham, NY 12110<br>1-800-572-6501 |
| <b>Issuing Date</b>  | 18-Sep-2014  |
| <b>Revision Date</b> | 18-Sep-2014  |
| <b>Revision Note</b> | Initial Release.   |

**General Disclaimer**

The information provided on this SDS is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guide for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered as a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other material or in any process, unless specified in the text.

**End of Safety Data Sheet**



August 25, 2014

Anthony Zografos  
DNA Trek  
3997 Lyman Road  
Oakland, CA 94602

**Email Anthony Zografos**

Re: Your Inquiry on DNATrax, ID system using small DNA sequences

Dear Mr. Zografos:

In response to your inquiry, dated July 14, 2014, about the regulatory status of DNATrax, our thinking on the status of DNATrax may be somewhat different from yours; however, the overall conclusion would be that the use of DNA in this fashion would meet GRAS (generally recognized as safe) criteria. Our understanding is that DNATrax utilizes small defined DNA segments of around 100 bases (you specifically mention the thermophilic bacterium *Thermatoga maritima* as one source of DNA in your submission) as identifiers that could be applied to fruit and vegetables to encode information that would identify the companies involved in the processing and distribution of the commodities.

In its Statement of Policy: Food Derived From New Plant Varieties (57 FR 22984, May 29, 1992), the agency stated the following:

With respect to transferred genetic material (nucleic acids), generally FDA does not anticipate that transferred genetic material would itself be subject to food additive regulation. Nucleic acids are present in the cells of every living organism, including every plant and animal used for food by humans or animals, and do not raise a safety concern as a component of food. In regulatory terms, such material is presumed to be GRAS. Although the guidance provided in section VII. calls for a good understanding of the identity of the genetic material being transferred through genetic modification techniques, FDA does not expect that there will be any serious question about the GRAS status of transferred genetic material.

Consequently, based on its ubiquity in food, FDA concluded that nucleic acids themselves do not raise safety concerns. While this use of nucleic acids would be distinct from the use of genetic material in plant cells or other food cells, the inherent rationale would still apply. Moreover, the small size of the nucleic acids involved would not ordinarily be expected to remain intact after digestion or be biologically active.

Further, the carriers you describe would ordinarily also be considered GRAS, in fact, some have been affirmed as GRAS by the agency in years past (In Title 21 of the Code of Federal Regulations, maltodextrin is affirmed GRAS in section 184.1444, salt is mentioned in section 182.1(a) as a substance the Commissioner regards as safe for its intended use). Starches, while not specified in the regulations as direct food ingredients have a long history of use in foods and would meet history of common use in food criteria as discussed in the report of the Select Committee on GRAS Substances on uses of starches in packaging materials in 1979.

Based on these criteria, we conclude that the DNA and carriers and other substances used in DNATrax would be safely used as a tracer/identifier as described in the description dated June 12, 2014.

Sincerely yours,

**Robert I.  
Merker -S**

Digitally signed by Robert I. Merker -S  
DN: c=US, o=U.S. Government, ou=HHS,  
ou=FDA, ou=People,  
0.9.2342.19200300.100.1.1=1300070407,  
cn=Robert I. Merker -S  
Date: 2014.08.25 08:16:00 -04'00'

Robert I. Merker, Ph.D.  
Supervisory Consumer Safety Officer  
Division of Biotechnology  
and GRAS Notice Review  
Office of Food Additive Safety  
Center for Food Safety  
and Applied Nutrition

# Maltodextrin

sc-207840

## Material Safety Data Sheet



Hazard Alert Code  
Key:

EXTREME

HIGH

MODERATE

LOW

## Section 1 - CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

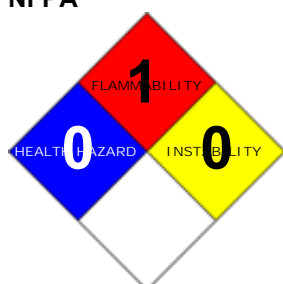
### PRODUCT NAME

Maltodextrin

### STATEMENT OF HAZARDOUS NATURE

Not considered a hazardous substance according to OSHA 29 CFR 1910.1200.

### NFPA



### SUPPLIER

Company: Santa Cruz Biotechnology, Inc.

Address:

2145 Delaware Ave

Santa Cruz, CA 95060

Telephone: 800.457.3801 or 831.457.3800

Emergency Tel: CHEMWATCH: From within the US and  
Canada: 877-715-9305

Emergency Tel: From outside the US and Canada: +800 2436  
2255 (1-800-CHEMCALL) or call +613 9573 3112

### PRODUCT USE

Food additive, bulking agent, binder, film former and carrier.

### SYNONYMS

(C<sub>6</sub>H<sub>10</sub>O<sub>5</sub>)<sub>n</sub>, "Glucidex 12", carbohydrate

## Section 2 - HAZARDS IDENTIFICATION

### CANADIAN WHMIS SYMBOLS

None

### EMERGENCY OVERVIEW RISK

### POTENTIAL HEALTH EFFECTS

### ACUTE HEALTH EFFECTS

### SWALLOWED

■ The material has NOT been classified as "harmful by ingestion". This is because of the lack of corroborating animal or human evidence. The material may still be damaging to the health of the individual, following ingestion, especially where pre-existing organ (e.g. liver, kidney) damage is evident. Present definitions of harmful or toxic substances are generally based on doses producing mortality (death) rather than those producing morbidity (disease, ill-health). Gastrointestinal tract discomfort may produce nausea and vomiting. In an occupational setting however, unintentional ingestion is not thought to be cause for concern.

### EYE

■ Although the material is not thought to be an irritant, direct contact with the eye may cause transient discomfort characterized by tearing or conjunctival redness (as with windburn). Slight abrasive damage may also result. The material may produce foreign body irritation in certain individuals.

### SKIN

■ The material is not thought to produce adverse health effects or skin irritation following contact (as classified using animal

models). Nevertheless, good hygiene practice requires that exposure be kept to a minimum and that suitable gloves be used in an occupational setting.

■ Open cuts, abraded or irritated skin should not be exposed to this material.

■ Entry into the blood-stream, through, for example, cuts, abrasions or lesions, may produce systemic injury with harmful effects. Examine the skin prior to the use of the material and ensure that any external damage is suitably protected.

#### INHALED

■ The material is not thought to produce adverse health effects or irritation of the respiratory tract (as classified using animal models). Nevertheless, good hygiene practice requires that exposure be kept to a minimum and that suitable control measures be used in an occupational setting.

■ Persons with impaired respiratory function, airway diseases and conditions such as emphysema or chronic bronchitis, may incur further disability if excessive concentrations of particulate are inhaled.

#### CHRONIC HEALTH EFFECTS

■ Long-term exposure to the product is not thought to produce chronic effects adverse to the health (as classified using animal models); nevertheless exposure by all routes should be minimized as a matter of course.

Long term exposure to high dust concentrations may cause changes in lung function i.e. pneumoconiosis; caused by particles less than 0.5 micron penetrating and remaining in the lung. Prime symptom is breathlessness; lung shadows show on X-ray.

### Section 3 - COMPOSITION / INFORMATION ON INGREDIENTS

#### HAZARD RATINGS

|               |   | Min | Max |
|---------------|---|-----|-----|
| Flammability: | 1 |     |     |
| Toxicity:     | 0 |     |     |
| Body Contact: | 0 |     |     |
| Reactivity:   | 1 |     |     |
| Chronic:      | 0 |     |     |

Min/Nil=0  
Low=1  
Moderate=2  
High=3  
Extreme=4

| NAME         | CAS RN    | %   |
|--------------|-----------|-----|
| maltodextrin | 9050-36-6 | >99 |

### Section 4 - FIRST AID MEASURES

#### SWALLOWED

■

- Immediately give a glass of water.
- First aid is not generally required. If in doubt, contact a Poisons Information Center or a doctor.

#### EYE

■ If this product comes in contact with eyes:

- Wash out immediately with water.
- If irritation continues, seek medical attention.
- Removal of contact lenses after an eye injury should only be undertaken by skilled personnel.

#### SKIN

■ If skin or hair contact occurs:

- Flush skin and hair with running water (and soap if available).
- Seek medical attention in event of irritation.

#### INHALED

■

- If dust is inhaled, remove from contaminated area.
- Encourage patient to blow nose to ensure clear passage of breathing.
- If irritation or discomfort persists seek medical attention.

#### NOTES TO PHYSICIAN

■ Treat symptomatically.

### Section 5 - FIRE FIGHTING MEASURES

|                             |                |
|-----------------------------|----------------|
| Vapour Pressure (mmHG):     | Negligible     |
| Upper Explosive Limit (%):  | Not available. |
| Specific Gravity (water=1): | 1.60 approx.   |
| Lower Explosive Limit (%):  | 0.05 g/l       |

#### EXTINGUISHING MEDIA

■

- Foam.
- Dry chemical powder.
- BCF (where regulations permit).
- Carbon dioxide.
- Water spray or fog - Large fires only.

## **FIRE FIGHTING**

- 
- Alert Emergency Responders and tell them location and nature of hazard.
- Wear breathing apparatus plus protective gloves.
- Prevent, by any means available, spillage from entering drains or water course.
- Use water delivered as a fine spray to control fire and cool adjacent area.
- DO NOT approach containers suspected to be hot.
- Cool fire exposed containers with water spray from a protected location.
- If safe to do so, remove containers from path of fire.
- Equipment should be thoroughly decontaminated after use.

## **GENERAL FIRE HAZARDS/HAZARDOUS COMBUSTIBLE PRODUCTS**

- 
- Combustible solid which burns but propagates flame with difficulty.
- Avoid generating dust, particularly clouds of dust in a confined or unventilated space as dusts may form an explosive mixture with air, and any source of ignition, i.e. flame or spark, will cause fire or explosion. Dust clouds generated by the fine grinding of the solid are a particular hazard; accumulations of fine dust may burn rapidly and fiercely if ignited.
- Dry dust can be charged electrostatically by turbulence, pneumatic transport, pouring, in exhaust ducts and during transport.
- Build-up of electrostatic charge may be prevented by bonding and grounding.
- Powder handling equipment such as dust collectors, dryers and mills may require additional protection measures such as explosion venting.

Combustion products include: carbon monoxide (CO), carbon dioxide (CO<sub>2</sub>), other pyrolysis products typical of burning organic material.

## **FIRE INCOMPATIBILITY**

- 
- Avoid contamination with oxidizing agents i.e. nitrates, oxidizing acids, chlorine bleaches, pool chlorine etc. as ignition may result.

## **PERSONAL PROTECTION**

Glasses:

Chemical goggles.

Gloves:

Respirator:

Particulate

## **Section 6 - ACCIDENTAL RELEASE MEASURES**

### **MINOR SPILLS**

- 
- Clean up all spills immediately.
- Avoid contact with skin and eyes.
- Wear impervious gloves and safety glasses.
- Use dry clean up procedures and avoid generating dust.
- Sweep up or vacuum up (consider explosion-proof machines designed to be grounded during storage and use).
- Place spilled material in clean, dry, sealable, labeled container.

### **MAJOR SPILLS**

- 
- Clear area of personnel and move upwind.
- Alert Emergency Responders and tell them location and nature of hazard.
- Control personal contact by using protective equipment and dust respirator.
- Prevent spillage from entering drains, sewers or water courses.
- Avoid generating dust.
- Sweep, shovel up.
- Recover product wherever possible.
- Put residues in labeled plastic bags or other containers for disposal.
- If contamination of drains or waterways occurs, advise emergency services.

## **ACUTE EXPOSURE GUIDELINE LEVELS (AEGl) (in ppm)**

AEGl 1: The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic nonsensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.

AEGl 2: The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.

AEGl 3: The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death.

## **Section 7 - HANDLING AND STORAGE**

### **PROCEDURE FOR HANDLING**

- 
- Limit all unnecessary personal contact.
- Wear protective clothing when risk of exposure occurs.
- Use in a well-ventilated area.

- Avoid contact with incompatible materials.
- When handling, DO NOT eat, drink or smoke.
- Keep containers securely sealed when not in use.
- Avoid physical damage to containers.
- Always wash hands with soap and water after handling.
- Work clothes should be laundered separately.
- Use good occupational work practice.
- Observe manufacturer's storing and handling recommendations.
- Atmosphere should be regularly checked against established exposure standards to ensure safe working conditions are maintained.

Empty containers may contain residual dust which has the potential to accumulate following settling. Such dusts may explode in the presence of an appropriate ignition source.

- Do NOT cut, drill, grind or weld such containers
- In addition ensure such activity is not performed near full, partially empty or empty containers without appropriate workplace safety authorisation or permit.

## RECOMMENDED STORAGE METHODS

- Lined metal can, Lined metal pail/drum
- Plastic pail
- Polyliner drum
- Packing as recommended by manufacturer.
- Check all containers are clearly labeled and free from leaks.

## STORAGE REQUIREMENTS

- Store in original containers.
- Keep containers securely sealed.
- Store in a cool, dry, well-ventilated area.
- Store away from incompatible materials and foodstuff containers.
- Protect containers against physical damage and check regularly for leaks.
- Observe manufacturer's storing and handling recommendations.

## SAFE STORAGE WITH OTHER CLASSIFIED CHEMICALS



X: Must not be stored together

O: May be stored together with specific preventions

+: May be stored together

## Section 8 - EXPOSURE CONTROLS / PERSONAL PROTECTION

### EXPOSURE CONTROLS

| Source   | Material  | TWA<br>ppm | TWA<br>mg/m <sup>3</sup> | STEL<br>ppm | STEL<br>mg/m <sup>3</sup> | Peak<br>ppm | Peak<br>mg/m <sup>3</sup> | TWA<br>F/CC | Notes |
|--|---|------------|--------------------------|-------------|---------------------------|-------------|---------------------------|-------------|-------|
| US - Oregon Permissible Exposure Limits (Z3)                                     | maltodextrin (Inert or Nuisance Dust: (d) Total dust)                             |            | 10                       |             |                           |             |                           |             | *     |
| US OSHA Permissible Exposure Levels (PELs) - Table Z3                            | maltodextrin (Inert or Nuisance Dust: (d) Respirable fraction)                    |            | 5                        |             |                           |             |                           |             |       |
| US OSHA Permissible Exposure Levels (PELs) - Table Z3                            | maltodextrin (Inert or Nuisance Dust: (d) Total dust)                             |            | 15                       |             |                           |             |                           |             |       |
| US - Hawaii Air Contaminant Limits   | maltodextrin (Particulates not otherwise regulated - Total dust)                  |            | 10                       |             |                           |             |                           |             |       |
| US - Hawaii Air Contaminant Limits   | maltodextrin (Particulates not otherwise regulated - Respirable fraction)         |            | 5                        |             |                           |             |                           |             |       |
| US - Oregon Permissible Exposure Limits (Z3)                                     | maltodextrin (Inert or Nuisance Dust: (d) Respirable fraction)                    |            | 5                        |             |                           |             |                           |             | *     |
| US - Tennessee Occupational Exposure Limits - Limits For Air Contaminants        | maltodextrin (Particulates not otherwise regulated Respirable fraction)           |            | 5                        |             |                           |             |                           |             |       |
| US - Wyoming Toxic and Hazardous Substances Table Z1 Limits for Air Contaminants | maltodextrin (Particulates not otherwise regulated (PNOR)(f)-Respirable fraction) |            | 5                        |             |                           |             |                           |             |       |
| US - Michigan Exposure Limits for Air Contaminants                               | maltodextrin (Particulates not otherwise regulated, Respirable dust)              |            | 5                        |             |                           |             |                           |             |       |



## MATERIAL DATA

### MALTODEXTRIN:

■ These "dusts" have little adverse effect on the lungs and do not produce toxic effects or organic disease. Although there is no dust which does not evoke some cellular response at sufficiently high concentrations, the cellular response caused by P.N.O.C.s has the following characteristics:

- the architecture of the air spaces remain intact,
- scar tissue (collagen) is not synthesised to any degree,
- tissue reaction is potentially reversible.

Extensive concentrations of P.N.O.C.s may:

- seriously reduce visibility,
- cause unpleasant deposits in the eyes, ears and nasal passages,
- contribute to skin or mucous membrane injury by chemical or mechanical action, per se, or by the rigorous skin cleansing procedures necessary for their removal. [ACGIH]

This limit does not apply:

- to brief exposures to higher concentrations
- nor does it apply to those substances that may cause physiological impairment at lower concentrations but for which a TLV has as yet to be determined.

This exposure standard applies to particles which

- are insoluble or poorly soluble\* in water or, preferably, in aqueous lung fluid (if data is available) and
- have a low toxicity (i.e.. are not cytotoxic, genotoxic, or otherwise chemically reactive with lung tissue, and do not emit ionizing radiation, cause immune sensitization, or cause toxic effects other than by inflammation or by a mechanism of lung overload)

## PERSONAL PROTECTION



Consult your EHS staff for recommendations

### EYE

- 
- Safety glasses with side shields
- Chemical goggles.
- Contact lenses pose a special hazard; soft lenses may absorb irritants and all lenses concentrate them.

### HANDS/FEET

■ Suitability and durability of glove type is dependent on usage. Important factors in the selection of gloves include: such as:

- frequency and duration of contact,
- chemical resistance of glove material,
- glove thickness and
- dexterity

Select gloves tested to a relevant standard (e.g. Europe EN 374, US F739).

- When prolonged or frequently repeated contact may occur, a glove with a protection class of 5 or higher (breakthrough time greater than 240 minutes according to EN 374) is recommended.
- When only brief contact is expected, a glove with a protection class of 3 or higher (breakthrough time greater than 60 minutes according to EN 374) is recommended.
- Contaminated gloves should be replaced.

Gloves must only be worn on clean hands. After using gloves, hands should be washed and dried thoroughly. Application of a non-perfumed moisturiser is recommended.

Experience indicates that the following polymers are suitable as glove materials for protection against undissolved, dry solids, where abrasive particles are not present.

- polychloroprene
- nitrile rubber
- butyl rubber
- fluorocautchouc
- polyvinyl chloride

Gloves should be examined for wear and/ or degradation constantly.

### OTHER

■ No special equipment needed when handling small quantities.

#### OTHERWISE:

- Overalls.
- Barrier cream.
- Eyewash unit.

- 
- Respirators may be necessary when engineering and administrative controls do not adequately prevent exposures.
- The decision to use respiratory protection should be based on professional judgment that takes into account toxicity information, exposure measurement data, and frequency and likelihood of the worker's exposure - ensure users are not subject to high thermal loads which may result in heat stress or distress due to personal protective equipment (powered, positive flow, full face apparatus may be an option).
- Published occupational exposure limits, where they exist, will assist in determining the adequacy of the selected respiratory. These may be government mandated or vendor recommended.
- Certified respirators will be useful for protecting workers from inhalation of particulates when properly selected and fit tested as part of a complete respiratory protection program.
- Use approved positive flow mask if significant quantities of dust becomes airborne.
- Try to avoid creating dust conditions.

## RESPIRATOR

| Protection Factor | Half-Face Respirator | Full-Face Respirator | Powered Air Respirator |
|-------------------|----------------------|----------------------|------------------------|
| 10 x PEL          | P1                   | -                    | PAPR-P1                |
|                   | Air-line*            | -                    | -                      |
| 50 x PEL          | Air-line**           | P2                   | PAPR-P2                |
| 100 x PEL         | -                    | P3                   | -                      |
|                   | -                    | Air-line*            | -                      |
| 100+ x PEL        | -                    | Air-line**           | PAPR-P3                |

\* - Negative pressure demand \*\* - Continuous flow

Explanation of Respirator Codes:

Class 1 low to medium absorption capacity filters.

Class 2 medium absorption capacity filters.

Class 3 high absorption capacity filters.

PAPR Powered Air Purifying Respirator (positive pressure) cartridge.

Type A for use against certain organic gases and vapors.

Type AX for use against low boiling point organic compounds (less than 65°C).

Type B for use against certain inorganic gases and other acid gases and vapors.

Type E for use against sulfur dioxide and other acid gases and vapors.

Type K for use against ammonia and organic ammonia derivatives

Class P1 intended for use against mechanically generated particulates of sizes most commonly encountered in industry, e.g. asbestos, silica.

Class P2 intended for use against both mechanically and thermally generated particulates, e.g. metal fume.

Class P3 intended for use against all particulates containing highly toxic materials, e.g. beryllium.

The local concentration of material, quantity and conditions of use determine the type of personal protective equipment required.

Use appropriate NIOSH-certified respirator based on informed professional judgement. In conditions where no reasonable estimate of exposure can be made, assume the exposure is in a concentration IDLH and use NIOSH-certified full face pressure demand SCBA with a minimum service life of 30 minutes, or a combination full facepiece pressure demand SAR with auxiliary self-contained air supply. Respirators provided only for escape from IDLH atmospheres shall be NIOSH-certified for escape from the atmosphere in which they will be used.

## ENGINEERING CONTROLS

- Local exhaust ventilation is required where solids are handled as powders or crystals; even when particulates are relatively large, a certain proportion will be powdered by mutual friction.
- Exhaust ventilation should be designed to prevent accumulation and recirculation of particulates in the workplace.
- If in spite of local exhaust an adverse concentration of the substance in air could occur, respiratory protection should be considered. Such protection might consist of:
  - particle dust respirators, if necessary, combined with an absorption cartridge;
  - filter respirators with absorption cartridge or canister of the right type;
  - fresh-air hoods or masks
- Build-up of electrostatic charge on the dust particle, may be prevented by bonding and grounding.
- Powder handling equipment such as dust collectors, dryers and mills may require additional protection measures such as explosion venting.

Air contaminants generated in the workplace possess varying "escape" velocities which, in turn, determine the "capture velocities" of fresh circulating air required to efficiently remove the contaminant.

| Type of Contaminant:   | Air Speed:                   |
|--|------------------------------|
| direct spray, spray painting in shallow booths, drum filling, conveyer loading, crusher dusts, gas discharge (active generation into zone of rapid air motion) | 1-2.5 m/s (200-500 f/min.)   |
| grinding, abrasive blasting, tumbling, high speed wheel generated dusts (released at high initial velocity into zone of very high rapid air motion).           | 2.5-10 m/s (500-2000 f/min.) |

Within each range the appropriate value depends on:

| Lower end of the range                                    | Upper end of the range           |
|---|----------------------------------|
| 1: Room air currents minimal or favorable to capture      | 1: Disturbing room air currents  |
| 2: Contaminants of low toxicity or of nuisance value only | 2: Contaminants of high toxicity |
| 3: Intermittent, low production.                          | 3: High production, heavy use    |
| 4: Large hood or large air mass in motion                 | 4: Small hood-local control only |

Simple theory shows that air velocity falls rapidly with distance away from the opening of a simple extraction pipe. Velocity generally decreases with the square of distance from the extraction point (in simple cases). Therefore the air speed at the extraction point should be adjusted, accordingly, after reference to distance from the contaminating source. The air velocity at the extraction fan, for example, should be a minimum of 4-10 m/s (800-2000 f/min) for extraction of crusher dusts generated 2 meters distant from the extraction point. Other mechanical considerations, producing performance deficits within the extraction apparatus, make it essential that theoretical air velocities are multiplied by factors of 10 or more when extraction systems are installed or used.

## Section 9 - PHYSICAL AND CHEMICAL PROPERTIES

### PHYSICAL PROPERTIES

Solid.

Mixes with water.

| State              | Divided solid   | Molecular Weight          | Not applicable. |
|--------------------|-----------------|---------------------------|-----------------|
| Melting Range (°F) | Not applicable. | Viscosity                 | Not Applicable  |
| Boiling Range (°F) | Not applicable. | Solubility in water (g/L) | Soluble.        |

|                           |                |                                |                |
|---------------------------|----------------|--------------------------------|----------------|
| Flash Point (°F)          | Not available  | pH (1% solution)               | Not available. |
| Decomposition Temp (°F)   | Not available. | pH (as supplied)               | Not applicable |
| Autoignition Temp (°F)    | 770            | Vapour Pressure (mmHG)         | Negligible     |
| Upper Explosive Limit (%) | Not available. | Specific Gravity (water=1)     | 1.60 approx.   |
| Lower Explosive Limit (%) | 0.05 g/l       | Relative Vapor Density (air=1) | Not Applicable |
| Volatile Component (%vol) | Negligible     | Evaporation Rate               | Not applicable |

## APPEARANCE

Fine white powder with a bland odour; soluble in water.

## Section 10 - CHEMICAL STABILITY

### CONDITIONS CONTRIBUTING TO INSTABILITY

- Product is considered stable and hazardous polymerization will not occur.

### STORAGE INCOMPATIBILITY

- Avoid contamination of water, foodstuffs, feed or seed.
- Avoid reaction with oxidizing agents.

For incompatible materials - refer to Section 7 - Handling and Storage.

## Section 11 - TOXICOLOGICAL INFORMATION

maltodextrin

### TOXICITY AND IRRITATION

- Not available. Refer to individual constituents.

## Section 12 - ECOLOGICAL INFORMATION

Refer to data for ingredients, which follows:

MALTODEXTRIN:

## Section 13 - DISPOSAL CONSIDERATIONS

### Disposal Instructions

All waste must be handled in accordance with local, state and federal regulations.

! Legislation addressing waste disposal requirements may differ by country, state and/ or territory. Each user must refer to laws operating in their area. In some areas, certain wastes must be tracked.

A Hierarchy of Controls seems to be common - the user should investigate:

- Reduction
- Reuse
- Recycling
- Disposal (if all else fails)

This material may be recycled if unused, or if it has not been contaminated so as to make it unsuitable for its intended use. Shelf life considerations should also be applied in making decisions of this type. Note that properties of a material may change in use, and recycling or reuse may not always be appropriate.

DO NOT allow wash water from cleaning equipment to enter drains. Collect all wash water for treatment before disposal.

- Recycle wherever possible.
- Consult manufacturer for recycling options or consult Waste Management Authority for disposal if no suitable treatment or disposal facility can be identified.
- Dispose of by: Burial in a licensed land-fill or Incineration in a licensed apparatus (after admixture with suitable combustible material)
- Decontaminate empty containers. Observe all label safeguards until containers are cleaned and destroyed.

## Section 14 - TRANSPORTATION INFORMATION

NOT REGULATED FOR TRANSPORT OF DANGEROUS GOODS: DOT, IATA, IMDG

## Section 15 - REGULATORY INFORMATION

**maltodextrin (CAS: 9050-36-6) is found on the following regulatory lists;**

"Canada Domestic Substances List (DSL)", "OECD Representative List of High Production Volume (HPV) Chemicals", "US EPA High Production Volume Program Chemical List", "US Food Additive Database", "US Toxic Substances Control Act (TSCA) - Inventory", "US TSCA Section 8 (a) Inventory Update Rule (IUR) - Partial Exemptions"

## Section 16 - OTHER INFORMATION

*Reasonable care has been taken in the preparation of this information, but the author makes no warranty of merchantability or any other warranty, expressed or implied, with respect to this information. The author makes no representations and assumes no liability for any direct, incidental or consequential damages resulting from its use. For additional technical information please call our toxicology department on +800 CHEMCALL.*

■ Classification of the mixture and its individual components has drawn on official and authoritative sources as well as independent review by the Chemwatch Classification committee using available literature references. A list of reference resources used to assist the committee may be found at the [Chemwatch website](#).

■ The (M)SDS is a Hazard Communication tool and should be used to assist in the Risk Assessment. Many factors determine whether the reported Hazards are Risks in the workplace or other settings. Risks may be determined by reference to Exposures Scenarios. Scale of use, frequency of use and current or available engineering controls must be considered.

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Issue Date: Dec-17-2009

Print Date: Apr-21-2010

# Safety Data Sheet



9025 Technology Dr. Fishers, IN 46038 • Bangs Laboratories Website • Email for information • 800.387.0672

Revision Date: 05/28/2015

## SECTION 1: CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

### 1.1 Product Identifiers

Catalog Number   Product Name

SS02N-SS06N   Non-Functionalized Silica microparticles

### 1.2 Relevant identified uses of substance or mixture and uses advised against

Identified uses: Lab use

### 1.3 Details of the supplier of the safety data sheet

Company: Bangs Laboratories / A Division of Polysciences

9025 Technology Drive

Fishers, Indiana 46038

USA

Telephone: 800-387-0672

### 1.4 Emergency telephone number

Emergency Phone: 317-348-1673

## SECTION 2: HAZARDS IDENTIFICATION

### 2.1 Classification of the substance or mixture

**GHS Classification:** Non-Hazardous

**Signal word:** Non-Hazardous

**Pictogram:** NONE

#### Hazard Statement(s)

H000   Low hazard for normal industrial use  
P302+P352   IF ON SKIN: Wash with plenty of soap and water.  
P305B   IF IN EYES: Separate eyelids with fingertips.  
P313   Get medical advice/attention  
P351   Rinse cautiously with water for several minutes.

### 2.2 Hazard Ratings: These ratings are Bangs Laboratories, Inc.'s own assessments of the properties of the material using the ANSI/NFPA 704 Standard. Additional information can be found by consulting in the NFPA published ratings lists (List 325 and List 49). If no data is listed, the information is not available.

| <u>Health</u> | <u>Flammability</u> | <u>Reactivity</u> |
|---------------|---------------------|-------------------|
| 0             | 0                   | 0                 |

## SECTION 3: COMPOSITION / INFORMATION ON INGREDIENTS

| <i>Item#</i> | <i>Name</i>                | <i>CAS #</i> | <i>% in</i> |
|--------------|----------------------------|--------------|-------------|
| 1            | Water                      | 007732185    | 90≥         |
| 2            | Silicon dioxide, amorphous | 007631869    | ≤10         |

## SECTION 4: FIRST AID MEASURES

**Eyes:** In case of contact, immediately flush eyes with copious amounts of water for at least 15 minutes.

**Skin:** In case of contact, immediately wash skin with copious amounts of water for at least 15 minutes.

**Ingestion:** Contact physician immediately.

**Inhalation:** Remove to fresh air if effects occur. Consult medical personnel.

**Systemic:** Human effects not established. No specific antidote. Treatment based on sound judgment of physician and the individual reactions of the patient.

## SECTION 5: FIRE FIGHTING MEASURES

- 5.1 Extinguishing Media:** Not applicable
- 5.2 Special hazards arising from the substance or mixture:** Suspended material is not flammable.
- 5.3 Advice for firefighters:** Not applicable
- 5.4 Further Information:** No data available

## SECTION 6: ACCIDENTAL RELEASE MEASURES

### 6.1 Personal precautions, protective equipment and emergency procedures

Any information given below is considered to be in addition to internal guidelines for isolation of spill, containment of spill, removal of ignition source from immediate area, and collection for disposal of spill by trained, properly protected clean up personnel. Wear vinyl gloves, soak up spill in paper toweling, and rinse area with water. Put all generated waste into an approved container and dispose of as waste. Observe all applicable federal, state, and local disposal laws.

- 6.2 Environmental Precautions:** No special measures are indicated.
- 6.3 Methods and materials for containment and cleaning up:** No special measures are indicated.
- 6.4 Reference to other sections:** For disposal see section 13.

## SECTION 7: HANDLING AND STORAGE

### 7.1 Precautions for safe handling

Respiratory Protection: None normally needed. In cases where there is a likelihood of inhalation exposure to dried particles, wear a NIOSH-approved dust respirator.

### 7.2 Conditions for safe storage, including any incompatibilities

Ventilation: Good room ventilation is adequate for most operations.

Respiratory Protection: None normally needed. In cases where there is a likelihood of inhalation exposure to dried particles, wear a NIOSH-approved dust respirator.

### 7.3 Specific end use(s)

Storage: Store at 4-8°C. Keep refrigerated. Do not freeze. Keep container closed.

## SECTION 8: EXPOSURE CONTROLS AND PERSONAL PROTECTION

### 8.1 Control parameters

Respiratory Protection: None normally needed.

Wash / Hygienic Practices: Wash with soap and water when leaving work area and before eating, smoking, and using restroom facilities.

### 8.2 Exposure Controls: None Indicated

The use of eye protection in the form of safety glasses with side shields and the use of skin protection for hands in the form of gloves are considered minimum and non-discretionary in work places and laboratories. Any recommended personal protection equipment or environmental equipment is to be considered as additional to safety glasses and gloves. Chemical-resistant gloves should be worn whenever this material is handled. The glove material has to be impermeable and resistant to the product. Gloves should be removed and replaced immediately if there is any indication of degradation or chemical breakthrough. Rinse and remove gloves immediately after use. Wash hands with soap and water. All glove recommendations presume that the risk of exposure is through splash and not internal immersion of the hands into the product. Since glove permeation data does not exist for this material, no recommendation for the glove material can be given for the product. Permeation data must be obtained from the glove manufacturer to determine if the glove is suitable for the task.

## SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

### 9.1 Information on basic physical and chemical properties

|                      |                      |
|----------------------|----------------------|
| Boiling Point:       | 100°C / 212°F        |
| Density (particles): | ~2.0 g/cc            |
| Solubility:          | dispersible in water |
| Appearance:          | white slurry         |

### 9.2 Other safety information: None

## SECTION 10: STABILITY AND REACTIVITY

- 10.1 Reactivity:** No data available
- 10.2 Chemical Stability:** Stable under recommended storage conditions
- 10.3 Possibility of hazardous reactions:** No data available
- 10.4 Conditions to avoid:** Product may irreversibly aggregate if frozen.
- 10.5 Incompatible materials:** Reacts with hydrogen fluoride, fluorine, oxygen difluoride, chlorine trifluoride, strong acids, strong bases and oxidizers.

## SECTION 11: TOXICOLOGICAL INFORMATION

- 11.1 Information on toxicological effects:** To the best of our knowledge, the chemical, physical, and toxic properties of this product have not been thoroughly investigated. This product is synthetic amorphous silica and is not crystalline in nature.

## SECTION 12: ECOLOGICAL INFORMATION

No Data

## SECTION 13: DISPOSAL CONSIDERATIONS

**13.1 Waste treatment methods:** The following chart lists the status of the chemical and its components in reference to 40 CFR Part 261.33. If the product is listed by code number, the substance may be subject to special federal and state disposal regulations. If no codes are listed, the material must be disposed of in compliance with all Federal, State, and Local Regulations.

| <i>CAS #</i> | <i>Waste Code</i> | <i>Regulated Name</i> |
|--------------|-------------------|-----------------------|
| 007732185    | not listed        | not listed            |
| 007631869    | not listed        | not listed            |

## SECTION 14: TRANSPORT INFORMATION

Refer to bill of lading or container label for DOT or other transportation hazard classification, if any.

## SECTION 15: REGULATORY INFORMATION

All components of this product are on the TSCA public inventory.

Prop 65: Column A identifies those items which are known to the State of California to cause cancer. Column B identifies those which are known to the State of California to cause reproductive toxicity.

| <i>CAS #</i> | <i>Column A</i> | <i>Column B</i> |
|--------------|-----------------|-----------------|
| 007732185    | no              | no              |
| 007631869    | no              | no              |

**SARA Toxic Release Chemicals** (as defined in Section 313 of SARA Title III): This list identifies the toxic chemicals, including their de minimis concentrations for which reporting is required under Section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA). This list is also referred to as the Toxic Release Inventory (TRI) List.

| <i>CAS #</i> | <i>Regulated Name</i> | <i>de minimis conc %</i> | <i>Rep. Thres.</i> |
|--------------|-----------------------|--------------------------|--------------------|
| 007732185    | not listed            | not listed               | not listed         |
| 007631869    | not listed            | not listed               | not listed         |

**SARA Extremely Hazardous Substances and TPQs:** This list identifies hazardous substances regulated under Section 302 of SARA Title III with their TPQs (in pounds), as listed in 40 CFR 355, Appendices A and B.

| <i>CAS #</i> | <i>Regulated Name</i> | <i>TPQ (pounds)</i> | <i>EHS-RQ (pounds)</i> |
|--------------|-----------------------|---------------------|------------------------|
| 007732185    | not listed            | not listed          | not listed             |
| 007631869    | not listed            | not listed          | not listed             |

## SECTION 16: OTHER INFORMATION

BANGS LABORATORIES, INC. provides the information contained herein in good faith, but makes no representation as to its comprehensiveness or accuracy. Individuals receiving this information must exercise their independent judgment in determining its appropriateness for a particular purpose.

BANGS LABORATORIES, INC. makes no representations or warranties, either expressed or implied, of merchantability or fitness for particular purposes with respect to the information set forth herein or to which the information refers. Accordingly, BANGS LABORATORIES, INC. will not be responsible for damages resulting from the use of or reliance upon this information.

Preparation Information:

Bangs Laboratories, Inc.

1-800-387-0672

**END OF SDS**



# Safety Data Sheet

Fluorescent Brightener 220, Technical grade

## 1. Identification

|                                 |  |
|---------------------------------|--|
| Product name                    | Fluorescent Brightener 220, Technical grade  |
| Catalog#                        | O241   |
| IUPAC name                      | tetrasodium;2-[[4-[bis(2-hydroxyethyl)amino]-6-(4-sulfonatoanilino)-1,3,5-triazin-2-yl]amino]-5-[(E)-2-[4-[[4-[bis(2-hydroxyethyl)amino]-6-(4-sulfonatoanilino)-1,3,5-triazin-2-yl]amino]-3-sulfonatophenyl]ethenyl]benzenesulfonate |
| Product use/Restrictions on use | For laboratory research use. Not for drug or household use.  |
| Company                         | AK Scientific, Inc.<br>30023 Ahern Ave.<br>Union City, CA 94587  |
| Telephone                       | (510) 429-8835   |
| Fax                             | (510) 429-8836   |
| Website                         | AK Scientific Website  |
| Emergency contact number:       | (510) 429-8835   |

## 2. Hazards Identification

### GHS Classification

No data available.

### Pictogram

No data available.

### Signal word

No data available.

### Hazard statement(s)

No data available.

### Precautionary statement(s)

No data available.

### Hazards not otherwise classified (HNOC) or not covered by GHS

No data available.

## 3. Composition/Information on Ingredients

Synonyms: No data available.

CAS#: [16470-24-9]

Purity: No data available.

EC#: 240-521-2

## 4. First Aid Measures

**General information:** Immediately remove any clothing contaminated by the product. Move out of dangerous area. Consult a physician and show this safety data sheet.

**Inhalation:** Move person to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Obtain medical aid.

**Skin contact:** Immediately flush skin with running water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. Obtain medical aid immediately.

**Eye contact:** Immediately flush open eyes with running water for at least 15 minutes. Obtain medical aid immediately.

**Ingestion:** Do NOT induce vomiting without medical advice. Rinse mouth with water. Never administer anything by mouth to an unconscious person. Obtain medical aid immediately.

**Most important symptoms and effects, both acute and delayed:** No further information available. Please see headings 2 and 11.

**Indication of any immediate medical attention and special treatment needed:** No further information available.

## 5. Fire Fighting Measure

**Suitable extinguishing media:** Use water spray, dry chemical, carbon dioxide, or chemical foam.

**Specific hazards arising from the chemical:** Nitrogen oxides, Sulfur oxides, Carbon oxides, Sodium oxides



## Fluorescent Brightener 220, Technical grade

**Advice for firefighters:** As in any fire, wear a MSHA/NIOSH-approved or equivalent, pressure-demand, self-contained breathing apparatus and full protective gear. During a fire, irritating and highly toxic gases may be generated by thermal decomposition or combustion

---

## 6. Accidental Release Measures

**Personal precautions, protective equipment and emergency procedures:** Wear protective equipment and keep unprotected personnel away. Ensure adequate ventilation. Remove all sources of ignition. Prevent further leak or spill if safe to do so. For personal protective equipment, please refer to heading 8.

**Environmental precautions:** Do not let product enter drains, other waterways, or soil.

**Methods and materials for containment and cleaning up:** Prevent further leak or spill if safe to do so. Vacuum, sweep up, or absorb with inert material and place into a suitable disposal container. Consult local regulations for disposal. Also, see heading 13.

---

## 7. Handling and Storage

**Precautions for safe handling:** Avoid contact with skin, eyes, and personal clothing. Wash hands thoroughly after handling. Avoid breathing fumes. Use only with adequate ventilation. Wear suitable protective clothing, gloves, and eye/face protection. Keep away from sources of ignition. Minimize dust generation and accumulation. Keep container tightly closed. Open and handle container with care. Do not eat, drink, or smoke while handling.

**Conditions for safe storage, including any incompatibilities:** Store in a tightly-closed container when not in use. Store in a cool, dry, well-ventilated area away from incompatible substances. Keep away from sources of ignition.

---

## 8. Exposure Controls/Personal Protection

### Exposure limits

OSHA PEL: No data available.

NIOSH REL: No data available.

ACGIH TLV: No data available.

**Appropriate engineering controls:** Avoid contact with skin, eyes, and clothing. Wash hands before breaks and immediately after handling the product. Facilities storing or utilizing this material should be equipped with an eyewash fountain. Use adequate ventilation to keep airborne concentrations low.

### Personal protection

Eyes: Wear chemical splash goggles.

Hand: Wear protective gloves.

Skin and body: Wear protective lab coat and boots.

Respiratory: Use NIOSH/MSHA or CEN approved respirator.

---

## 9. Physical and Chemical Properties

Physical State: No data available.

Molecular Formula: C<sub>40</sub>H<sub>40</sub>N<sub>12</sub>Na<sub>4</sub>O<sub>16</sub>S<sub>4</sub>

Molecular Weight: 1165.03

Odor: No data available.

pH: No data available.

Boiling Point Range: No data available.

Freezing/Melting Point: No data available.

Flash Point: No data available.

Evaporation Rate: No data available.

Flammability (solid, gas): Please see section 2.

Explosive limits: No data available.

Vapor Pressure: No data available.

Vapor Density: No data available.

Solubility: No data available.

Relative Density: No data available.

Refractive Index: No data available.

Volatility: No data available.

## Fluorescent Brightener 220, Technical grade

|                            |                    |
|----------------------------|--------------------|
| Auto-ignition temperature: | No data available. |
| Decomposition Temperature: | No data available. |
| Partition Coefficient:     | No data available. |

---

**10. Stability and Reactivity**

|                                    |  |
|------------------------------------|--|
| Reactivity                         | No data available.   |
| Chemical stability                 | Stable under recommended temperatures and pressures.         |
| Possibility of hazardous reactions | No data available.   |
| Conditions to avoid                | Dust generation.   |
| Incompatible materials             | Strong oxidizing agents.                                     |
| Hazardous decomposition products   | Nitrogen oxides, Sulfur oxides, Carbon oxides, Sodium oxides |

---

**11. Toxicological Information**

|  |  |
|--|--|
| RTECS#   | No data available.   |
| Acute toxicity   | No data available.   |
| Routes of exposure   | Inhalation, eye contact, skin contact, ingestion.  |
| Symptoms related to the physical, chemical and toxicological characteristics | Skin contact may result in inflammation characterized by itching, scaling, reddening, blistering, pain or dryness. Eye contact may result in redness, pain or severe eye damage. Inhalation may cause irritation of the lungs and respiratory system. Overexposure may result in serious illness or death. |

**Carcinogenicity**

|                     |  |
|---------------------|--|
| IARC                | Not classified.  |
| NTP                 | Not listed.  |
| OSHA                | Not listed.  |
| Acute toxic effects | Inflammation of the eye is characterized by redness, watering, and itching. Skin inflammation is characterized by itching, scaling, reddening, or, occasionally, blistering. |

---

**12. Ecological Information**

|                               |                    |
|-------------------------------|--------------------|
| Ecotoxicity                   | No data available. |
| Persistence and degradability | No data available. |
| Bioaccumulative potential     | No data available. |
| Mobility in soil              | No data available. |
| Other adverse effects         | No data available. |

---

**13. Disposal Considerations**

**Disposal of waste:** Chemical waste generators must determine whether a discarded chemical is classified as hazardous waste. US EPA guidelines for the classification determination are listed in 40 CFR 261.3. Additionally, waste generators must consult state and local hazardous waste regulations to ensure complete and accurate classification. Observe all federal, state and local regulations when disposing of the substance.

**Disposal of packaging:** Do not reuse containers. Dispose of as unused product.

---

**14. Transport Information****DOT (U.S.)**

|                            |                 |
|----------------------------|-----------------|
| UN number                  | Not applicable. |
| UN proper shipping name    | Not applicable. |
| Transport hazard class(es) | Not applicable. |
| Packing group              | Not applicable. |

---

**15. Regulatory Information**

TSCA Chemical Inventory: This product is on the EPA Toxic Substance Control Act (TSCA) inventory. The product is supplied solely for use in research and development by or under the supervision of a technically qualified individual as

## Fluorescent Brightener 220, Technical grade

|                            |   |
|----------------------------|---|
|                            | defined in 40 CFR 720 et seq. The health risks have not been fully determined. Any information that is or becomes available will be supplied on an SDS sheet. |
| California Proposition 65: | Not listed.   |
| EC#:                       | 240-521-2   |
| NFPA rating:               | <b>Health:</b>  |
|                            | <b>Flammability:</b>  |
|                            | <b>Instability:</b>   |

---

**16. Additional Information**

Revision Date: 12/22/2014

Printed Date: 2/11/2015

**Disclaimer:**

*The information above is believed to be accurate and represents the best information currently available to us. However, we make no warranty of merchantability or any other warranty, express or implied, with respect to such information, and we assume no liability resulting from its use. Users should make their own investigations to determine the suitability of the information for their particular purposes. In no event shall AK Scientific be liable for any claims, losses, or damages of any third party or for lost profits or any special, indirect, incidental, consequential or exemplary damages, howsoever arising, even if AK Scientific has been advised of the possibility of such damages.*

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## SAFETY DATA SHEET

Version 3.4  
Revision Date 07/02/2014  
Print Date 11/20/2014

---

1. PRODUCT AND COMPANY IDENTIFICATION

## 1.1 Product identifiers

Product name : Sulfur hexafluoride

Product Number : 295701

Brand : Aldrich

CAS-No. : 2551-62-4

## 1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses : Laboratory chemicals, Manufacture of substances

## 1.3 Details of the supplier of the safety data sheet

Company : Sigma-Aldrich  
3050 Spruce Street  
SAINT LOUIS MO 63103  
USA

Telephone : +1 800-325-5832

Fax : +1 800-325-5052

## 1.4 Emergency telephone number

Emergency Phone # : (314) 776-6555

---

2. HAZARDS IDENTIFICATION

## 2.1 Classification of the substance or mixture

**GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)**

Gases under pressure (Liquefied gas), H280

For the full text of the H-Statements mentioned in this Section, see Section 16.

## 2.2 GHS Label elements, including precautionary statements

Pictogram



Signal word : Warning

Hazard statement(s)

H280 : Contains gas under pressure; may explode if heated.

Precautionary statement(s)

P410 + P403 : Protect from sunlight. Store in a well-ventilated place.

## 2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none

---

3. COMPOSITION/INFORMATION ON INGREDIENTS

## 3.1 Substances

Formula : F<sub>6</sub>S

Molecular Weight : 146.06 g/mol

CAS-No. : 2551-62-4

EC-No. : 219-854-2

**Hazardous components**

| Component                  | Classification    | Concentration |
|----------------------------|-------------------|---------------|
| <b>Sulfur hexafluoride</b> |                   |               |
|                            | Press. Gas ; H280 | -             |

For the full text of the H-Statements mentioned in this Section, see Section 16.

---

## 4. FIRST AID MEASURES

### 4.1 Description of first aid measures

#### General advice

Consult a physician. Show this safety data sheet to the doctor in attendance. Move out of dangerous area.

#### If inhaled

If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

#### In case of skin contact

Wash off with soap and plenty of water. Consult a physician.

#### In case of eye contact

Flush eyes with water as a precaution.

#### If swallowed

Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

### 4.2 Most important symptoms and effects, both acute and delayed

The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

### 4.3 Indication of any immediate medical attention and special treatment needed

no data available

---

## 5. FIREFIGHTING MEASURES

### 5.1 Extinguishing media

#### Suitable extinguishing media

Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

### 5.2 Special hazards arising from the substance or mixture

Sulphur oxides, Hydrogen fluoride

### 5.3 Advice for firefighters

Wear self contained breathing apparatus for fire fighting if necessary.

### 5.4 Further information

Use water spray to cool unopened containers.

---

## 6. ACCIDENTAL RELEASE MEASURES

### 6.1 Personal precautions, protective equipment and emergency procedures

Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Evacuate personnel to safe areas.  
For personal protection see section 8.

### 6.2 Environmental precautions

Do not let product enter drains.

### 6.3 Methods and materials for containment and cleaning up

Clean up promptly by sweeping or vacuum.

### 6.4 Reference to other sections

For disposal see section 13.

---

## 7. HANDLING AND STORAGE

### 7.1 Precautions for safe handling

Normal measures for preventive fire protection.  
For precautions see section 2.2.

### 7.2 Conditions for safe storage, including any incompatibilities

Keep container tightly closed in a dry and well-ventilated place.

Contents under pressure.

### 7.3 Specific end use(s)

Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

## 8. EXPOSURE CONTROLS/PERSONAL PROTECTION

### 8.1 Control parameters

#### Components with workplace control parameters

| Component            | CAS-No.   | Value | Control parameters         | Basis   |
|----------------------|-----------|-------|----------------------------|---|
| Sulfur hexafluoride* | 2551-62-4 | TWA   | 1,000 ppm                  | USA. ACGIH Threshold Limit Values (TLV)   |
|                      |           |       | 1,000 ppm<br>6,000 mg/m3** | USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants      |
|                      |           |       | 1,000 ppm<br>6,000 mg/m3** | USA. OSHA - TABLE Z-1 Limits for Air Contaminants - 1910.1000                         |
|                      |           |       | 1,000 ppm<br>6,000 mg/m3** | USA. NIOSH Recommended Exposure Limits  |
|                      |           |       | 2.5 mg/m3***               | USA. Occupational Exposure Limits (OSHA) - Table Z-2 (Z37.28-1969) (Fluoride is dust) |

Remarks: \*Asphyxia

\*\*the value in mg/m3 is approximate.

\*\*\*May contain highly toxic sulfur pentafluoride as an impurity

#### Biological occupational exposure limits

| Component           | CAS-No.   | Value     | Control parameters | Specimen   | Basis                                     |
|---------------------|-----------|-----------|--------------------|--|---|
| Sulfur hexafluoride | 2551-62-4 | Fluorides | 3 mg/g             | In urine(sample time: Prior to shift (16 hours after                             | ACGIH - Biological Exposure Indices (BEI) |
|                     |           |           | 10 mg/g            | In urine (sample time: End of shift (As soon as possible after exposure ceases)) | ACGIH - Biological Exposure Indices (BEI) |

### 8.2 Exposure controls

#### Appropriate engineering controls

Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

#### Personal protective equipment

##### Eye/face protection

Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

##### Skin protection

Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Full contact

Material: butyl-rubber

Minimum layer thickness: 0.3 mm

Break through time: 480 min

Material tested: Butoject® (KCL 897 / Aldrich Z677647, Size M)

Splash contact

Material: butyl-rubber  
Minimum layer thickness: 0.3 mm  
Break through time: 480 min  
Material tested: Butoject® (KCL 897 / Aldrich Z677647, Size M)

data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail KCL sales, test method: EN374

If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

#### **Body Protection**

impervious clothing, The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

#### **Respiratory protection**

Where risk assessment shows air-purifying respirators are appropriate use a full-face respirator with multi-purpose combination (US) or type AXBEK (EN 14387) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

#### **Control of environmental exposure**

Do not let product enter drains.

---

## **9. PHYSICAL AND CHEMICAL PROPERTIES**

### **9.1 Information on basic physical and chemical properties**

- |   |  |
|---|--|
| a) Appearance                                   | Form: Liquefied gas  |
| b) Odour  | no data available  |
| c) Odour Threshold                              | no data available  |
| d) pH   | no data available  |
| e) Melting point/freezing point                 | Melting point/range: -50 °C (-58 °F) - lit.  |
| f) Initial boiling point and boiling range      | -64 °C (-83 °F) at 1 hPa (1 mmHg) - lit.   |
| g) Flash point                                  | not applicable   |
| h) Evapouration rate                            | no data available  |
| i) Flammability (solid, gas)                    | no data available  |
| j) Upper/lower flammability or explosive limits | no data available  |
| k) Vapour pressure                              | 29 hPa (22 mmHg) at 21.1 °C (70.0 °F)<br>22,057 hPa (16,544 mmHg) at 20 °C (68 °F) |
| l) Vapour density                               | 5.04 - (Air = 1.0)   |
| m) Relative density                             | no data available  |
| n) Water solubility                             | no data available  |
| o) Partition coefficient: n-octanol/water       | no data available  |
| p) Auto-ignition temperature                    | no data available  |
| q) Decomposition temperature                    | no data available  |
| r) Viscosity                                    | no data available  |

s) Explosive properties      no data available

t) Oxidizing properties      no data available

## 9.2 Other safety information

Relative vapour density      5.04 - (Air = 1.0)

---

## 10. STABILITY AND REACTIVITY

### 10.1 Reactivity

no data available

### 10.2 Chemical stability

Stable under recommended storage conditions.

### 10.3 Possibility of hazardous reactions

no data available

### 10.4 Conditions to avoid

no data available

### 10.5 Incompatible materials

Strong oxidizing agents

### 10.6 Hazardous decomposition products

Other decomposition products - no data available

In the event of fire: see section 5

---

## 11. TOXICOLOGICAL INFORMATION

### 11.1 Information on toxicological effects

#### Acute toxicity

no data available

Inhalation: no data available

Dermal: no data available

LD50 Intravenous - rabbit - 5,790 mg/kg

#### Skin corrosion/irritation

no data available

#### Serious eye damage/eye irritation

no data available

#### Respiratory or skin sensitisation

no data available

#### Germ cell mutagenicity

no data available

#### Carcinogenicity

| Organization | Classification |
|--------------|----------------|
|--------------|----------------|

|       |   |
|-------|---|
| IARC: | No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC. |
|-------|---|

|        |  |
|--------|--|
| ACGIH: | No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH. |
|--------|--|

|      |   |
|------|---|
| NTP: | No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP. |
|------|---|

|       |   |
|-------|---|
| OSHA: | No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA. |
|-------|---|

#### Reproductive toxicity

no data available

no data available



**Specific target organ toxicity - single exposure**

no data available

**Specific target organ toxicity - repeated exposure**

no data available

**Aspiration hazard**

no data available

**Additional Information**

RTECS: WS4900000

May be harmful., Nausea, Dizziness, Headache, Central nervous system depression

---

**12. ECOLOGICAL INFORMATION****12.1 Toxicity**

no data available

**12.2 Persistence and degradability**

no data available

**12.3 Bioaccumulative potential**

no data available

**12.4 Mobility in soil**

no data available

**12.5 Results of PBT and vPvB assessment**

PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

**12.6 Other adverse effects**

no data available

---

**13. DISPOSAL CONSIDERATIONS****13.1 Waste treatment methods****Product**

Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material.

**Contaminated packaging**

Dispose of as unused product.

---

**14. TRANSPORT INFORMATION****DOT (US)**

|                           |                     |
|---------------------------|---------------------|
| UN number: 1080           | Class: 2.2          |
| Proper shipping name:     | Sulfur hexafluoride |
| Marine pollutant:         | No                  |
| Poison Inhalation Hazard: | No                  |

**IMDG**

|                       |                             |
|-----------------------|-----------------------------|
| UN number: 1080       | Class: 2.2 EMS-No: F-C, S-V |
| Proper shipping name: | SULPHUR HEXAFLUORIDE        |
| Marine pollutant:     | No                          |

**IATA**

|                       |                             |
|-----------------------|-----------------------------|
| UN number: 1080       | Class: 2.2 EMS-No: F-C, S-V |
| Proper shipping name: | SULPHUR HEXAFLUORIDE        |

---

**15. REGULATORY INFORMATION****SARA 302 Components**

SARA 302: No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

**SARA 313 Components**

SARA 313: This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

**SARA 311/312 Hazards**

Sudden Release of Pressure Hazard

**Massachusetts Right To Know Components**

|                     | CAS-No.   | Revision Date |
|---------------------|-----------|---------------|
| Sulfur hexafluoride | 2551-62-4 | 1993-04-24    |

**Pennsylvania Right To Know Components**

|                     | CAS-No.   | Revision Date |
|---------------------|-----------|---------------|
| Sulfur hexafluoride | 2551-62-4 | 1993-04-24    |

**New Jersey Right To Know Components**

|                     | CAS-No.   | Revision Date |
|---------------------|-----------|---------------|
| Sulfur hexafluoride | 2551-62-4 | 1993-04-24    |

**California Prop. 65 Components**

This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

---

**16. OTHER INFORMATION****Full text of H-Statements referred to under sections 2 and 3.**

|            |   |
|------------|---|
| H280       | Contains gas under pressure; may explode if heated. |
| Press. Gas | Gases under pressure                                |

**HMIS Rating**

|                        |   |
|------------------------|---|
| Health hazard:         | 0 |
| Chronic Health Hazard: |   |
| Flammability:          | 0 |
| Physical Hazard        | 0 |

**NFPA Rating**

|                    |   |
|--------------------|---|
| Health hazard:     | 0 |
| Fire Hazard:       | 0 |
| Reactivity Hazard: | 0 |

**Further information**

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**Preparation Information**

Sigma-Aldrich Corporation  
Product Safety – Americas Region  
1-800-521-8956

Version: 3.4

Revision Date: 07/02/2014

Print Date: 11/20/2014

# Perfluoro (dimethylcyclobutane) : sc-264029

## MATERIAL SAFETY DATA SHEET

The Power to Question

### 1 Identification of substance:

**Product Name:** Perfluoro(dimethylcyclobutane)  
**Catalog Number:** sc-264029  
**Supplier:** Santa Cruz Biotechnology, Inc.  
2145 Delaware Avenue  
Santa Cruz, California 95060  
800.457.3801 or 831.457.3800  
**Emergency:** ChemWatch  
Within the US & Canada: 877-715-9305  
Outside the US & Canada: +800 2436 2255  
(1-800-CHEMCALL) or call +613 9573 3112

### 2 Hazard (s) identification

#### Classification of the substance or mixture

#### Classification according to Regulation (EC) No 1272/2008

The substance is not classified as hazardous to health or the environment according to the CLP regulation.

Classification according to Directive 67/548/EEC or Directive 1999/45/EC Not applicable

#### Information concerning particular hazards for human and environment:

Not applicable

No information known.

Hazards not otherwise classified No information known.

#### Label elements

Labelling according to Regulation (EC) No 1272/2008 Not applicable

Hazard pictograms Not applicable

Signal word Not applicable

Hazard statements Not applicable

WHMIS classification Not controlled

#### Classification system

HMIS ratings (scale 0-4)

(Hazardous Materials Identification System)

|            |
|------------|
| HEALTH     |
| FIRE       |
| REACTIVITY |

Health (acute effects) = 1

Flammability = 1

Physical Hazard = 1

#### Other hazards

#### Results of PBT and vPvB assessment

PBT: Not applicable.

vPvB: Not applicable.

### 3 Composition/information on ingredients

#### Chemical characterization: Substances

#### CAS# Description:

28677-00-1 Perfluorodimethylcyclobutane

#### Identification number(s):

EC number: 249-145-3

### 4 First-aid measures

#### Description of first aid measures

##### After inhalation

Supply fresh air. If required, provide artificial respiration. Keep patient warm.  
Seek immediate medical advice.

##### After skin contact

Immediately wash with water and soap and rinse thoroughly.

Seek immediate medical advice.

**After eye contact**

Rinse opened eye for several minutes under running water. Then consult a doctor.

**After swallowing** Seek medical treatment.

**Information for doctor**

**Most important symptoms and effects, both acute and delayed**

No further relevant information available.

**Indication of any immediate medical attention and special treatment needed**

No further relevant information available.

## 5 Fire- fighting measures

**Extinguishing media**

**Suitable extinguishing agents**

Carbon dioxide, extinguishing powder or water spray. Fight larger fires with water spray or alcohol resistant foam.

**Special hazards arising from the substance or mixture**

If this product is involved in a fire, the following can be released:

Carbon monoxide and carbon dioxide

Hydrogen fluoride (HF)

**Advice for firefighters**

**Protective equipment:**

Wear self-contained respirator.

Wear fully protective impervious suit.

## 6 Accidental release measures

**Personal precautions, protective equipment and emergency procedures**

Wear protective equipment. Keep unprotected persons away.

Ensure adequate ventilation

**Environmental precautions:**

Do not allow product to reach sewage system or any water course.

Do not allow to penetrate the ground/soil.

**Methods and material for containment and cleaning up :**

Absorb with liquid -binding material (sand, diatomite, acid binders, universal binders, sawdust).

**Prevention of secondary hazards:** No special measures required.

**Reference to other sections**

See Section 7 for information on safe handling

See Section 8 for information on personal protection equipment.

See Section 13 for disposal information.

## 7 Handling and storage

**Handling**

**Precautions for safe handling** Keep container tightly sealed.

**Information about protection against explosions and fires:** No information known.

**Conditions for safe storage, including any incompatibilities**

**Storage** Store at 4° C .

**Requirements to be met by storerooms and receptacles:** Refrigerate

**Information about storage in one common storage facility:**

Protect from heat.

Store away from oxidizing agents.

**Further information about storage conditions:**

Keep container tightly sealed.

Refrigerate

**Specific end use (s)** No further relevant information available.

## 8 Exposure controls/personal protection

**Additional information about design of technical systems:**

Properly operating chemical fume hood designed for hazardous chemicals and having an average face velocity of at least 100 feet per minute.

**Control parameters**

**Components with limit values that require monitoring at the workplace:**

The product does not contain any relevant quantities of materials with critical values that have to be monitored at the workplace.

**Additional information:** No data

**Exposure controls****Personal protective equipment****General protective and hygienic measures**

The usual precautionary measures for handling chemicals should be followed.

Keep away from foodstuffs, beverages and feed.

Remove all soiled and contaminated clothing immediately.

Wash hands before breaks and at the end of work.

Maintain an ergonomically appropriate working environment.

**Breathing equipment:**

Use suitable respirator when high concentrations are present.

Use suitable respiratory protective device in case of insufficient ventilation.

**Protection of hands:**

Impervious gloves

Check protective gloves prior to each use for their proper condition.

The selection of suitable gloves not only depends on the material, but also on quality.

Quality will vary from manufacturer to manufacturer.

**Eye protection:** Safety glasses

**Body protection:** Protective work clothing.

**9 Physical and chemical properties**

| <b>Property</b>                            | <b>Values</b>                                    |
|--|--|
| General Information                        |  |
| Form:                                      | Liquid   |
| Formula:                                   | C6F12  |
| Weight:                                    | 300.04   |
| pH- value:                                 | Not determined.                                  |
| Change in condition                        |  |
| Melting point/Melting range:               | Not determined.                                  |
| Boiling point/Boiling range:               | 45 oc (113 op )                                  |
| Sublimation temperature /start:            | Not determined                                   |
| Flammability (solid,gaseous)               | Not determined.                                  |
| Ignition temperature:                      | Not determined                                   |
| Decomposition temperature:                 | Not determined.                                  |
| Auto igniting:                             | Not determined.                                  |
| Danger of explosion:                       | Not determined                                   |
| Explosion limits:                          | Not determined.                                  |
| Lower:                                     | Not determined                                   |
| Upper:                                     |  |
| Vapor pressure:                            | Not determined                                   |
| Density at 20 °C (68 °F): Relative density | Not determined                                   |
| Vapor density Evaporation rate             |  |
|  | 1.62 g/cm <sup>3</sup> (13.519lbs/gal)           |
| Solubility in/Miscibility with Water:      | Not miscible or difficult to mix Not determined. |
| Partition coefficient (n-octanol/water):   | Not determined.                                  |
| Viscosity                                  |  |
| dynamic:                                   | Not determined.                                  |
| kinematic:                                 | Not determined.                                  |
| Other information                          | No further relevant information available.       |

**10 Stability and reactivity**

**Reactivity** No information known.

**Chemical stability** Stable under recommended storage conditions.

**Thermal decomposition / conditions to be avoided:**

Decomposition will not occur if used and stored according to specifications.

**Possibility of hazardous reactions** Reacts with strong oxidizing agents

**Incompatible materials:**

Oxidizing agents

Heat

**Hazardous decomposition products:**

Carbon monoxide and carbon dioxide

Hydrogen fluoride

## 11 Toxicological information

Information on toxicological effects

Acute toxicity: No effects known.

LD/LC50 values that are relevant for classification: No data

Skin irritation or corrosion: May cause irritation

Eye irritation or corrosion: May cause irritation

Sensitization: No sensitizing effects known.

Germ cell mutagenicity: No effects known.

Carcinogenicity:

No classification data on carcinogenic properties of this material is available from the EPA, IARC, NTP, OSHA or ACGIH.

Reproductive toxicity: No effects known.

Specific target organ system toxicity - repeated exposure: No effects known.

Specific target organ system toxicity - single exposure: No effects known.

Aspiration hazard: No effects known.

Additional toxicological information:

To the best of our knowledge the acute and chronic toxicity of this substance is not fully known.

## 12 Ecological information

Toxicity

Aquatic toxicity: No further relevant information available.

Persistence and degradability No further relevant information available.

Behavior in environmental systems:

Bioaccumulative potential No further relevant information available.

Mobility in soil No further relevant information available.

Additional ecological information:

General notes: Avoid transfer into the environment.

Results of PBT and vPvB assessment

PBT: Not applicable.

vPvB: Not applicable.

Other adverse effects No further relevant information available.

## 13 Disposal considerations

Waste treatment methods

Recommendation Consult state, local or national regulations to ensure proper disposal.

Uncleaned packagings:

Recommendation: Disposal must be made according to official regulations.

## 14 Transport information

|  |                 |
|--|-----------------|
| UN-Number<br>DOT, ADR, ADN, IMDG, IATA                                     | Not applicable  |
| UN proper shipping name<br>DOT, ADR, ADN, IMDG, IATA                       | Not applicable  |
| Transport hazard class(es)<br>DOT, ADR, ADN, IMDG, IATA<br>Class           | Not applicable  |
| Packing group<br>DOT, ADR, IMDG, IATA                                      | Not applicable  |
| Environmental hazards:   | Not applicable. |
| Special precautions for user   | Not applicable. |
| Transport in bulk according to Annex II of<br>MARPOL73/78 and the IBC Code | Not applicable. |
| Transport/Additional information:<br>DOT<br>Marine Pollutant (DOT):        | No              |

## 15 Regulatory information

Safety, health and environmental regulations/legislation specific for the substance or mixture

### National regulations

This product is not listed in the U.S. Environmental Protection Agency Toxic Substances Control Act Chemical Substance Inventory. Use of this product is restricted to research and development only. This product must be used by or directly under the supervision of a technically qualified individual as defined by TSCA. This product must not be used for commercial purposes or in formulations for commercial purposes.

Some or all of the components of this product are not listed on the Canadian Domestic Substances List (DSL) or the Canadian Non-Domestic Substances List (NDSL).

SARA Section 313 (specific toxic chemical listings) Substance is not listed.

### California Proposition 65

Prop 65 - Chemicals known to cause cancer Substance is not listed.

Prop 65 - Developmental toxicity Substance is not listed.

Prop 65 - Developmental toxicity, female Substance is not listed.

Prop 65 - Developmental toxicity, male Substance is not listed.

Information about limitation of use: For use only by technically qualified individuals.

### Other regulations, limitations and prohibitive regulations

Substances of very high concern (SVHC) according to REACH, Article 57

Substance is not listed.

REACH - Pre-registered substances Substance is listed.

Chemical safety assessment: A Chemical Safety Assessment has not been carried out.

## 16 Other information:

The above information is believed to be correct but does not purport to be complete and should be used only as a guide. The burden of safe use of this material rests entirely with the user.

## SAFETY DATA SHEET

Version 5.2  
Revision Date 06/25/2014  
Print Date 11/20/2014

---

**1. PRODUCT AND COMPANY IDENTIFICATION****1.1 Product identifiers**

Product name : Perfluoro(methylcyclohexane)

Product Number : 302937  
Brand : Aldrich

CAS-No. : 355-02-2

**1.2 Relevant identified uses of the substance or mixture and uses advised against**

Identified uses : Laboratory chemicals, Manufacture of substances

**1.3 Details of the supplier of the safety data sheet**

Company : Sigma-Aldrich  
3050 Spruce Street  
SAINT LOUIS MO 63103  
USA

Telephone : +1 800-325-5832  
Fax : +1 800-325-5052

**1.4 Emergency telephone number**

Emergency Phone # : (314) 776-6555

---

**2. HAZARDS IDENTIFICATION****2.1 Classification of the substance or mixture**

Not a hazardous substance or mixture.

**2.2 GHS Label elements, including precautionary statements**

Not a hazardous substance or mixture.

**2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none**

---

**3. COMPOSITION/INFORMATION ON INGREDIENTS****3.1 Substances**

Synonyms : (Trifluoromethyl)undecafluorocyclohexane

Formula : C<sub>7</sub>F<sub>14</sub>  
Molecular Weight : 350.05 g/mol  
CAS-No. : 355-02-2  
EC-No. : 206-573-5

No ingredients are hazardous according to OSHA criteria.  
No components need to be disclosed according to the applicable regulations.

---

**4. FIRST AID MEASURES****4.1 Description of first aid measures****If inhaled**

If breathed in, move person into fresh air. If not breathing, give artificial respiration.



**In case of skin contact**

Wash off with soap and plenty of water.

**In case of eye contact**

Flush eyes with water as a precaution.

**If swallowed**

Never give anything by mouth to an unconscious person. Rinse mouth with water.

**4.2 Most important symptoms and effects, both acute and delayed**

The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

**4.3 Indication of any immediate medical attention and special treatment needed**

no data available

---

**5. FIREFIGHTING MEASURES****5.1 Extinguishing media****Suitable extinguishing media**

Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

**5.2 Special hazards arising from the substance or mixture**

Carbon oxides, Hydrogen fluoride

**5.3 Advice for firefighters**

Wear self contained breathing apparatus for fire fighting if necessary.

**5.4 Further information**

no data available

---

**6. ACCIDENTAL RELEASE MEASURES****6.1 Personal precautions, protective equipment and emergency procedures**

Avoid breathing vapours, mist or gas.  
For personal protection see section 8.

**6.2 Environmental precautions**

Do not let product enter drains.

**6.3 Methods and materials for containment and cleaning up**

Keep in suitable, closed containers for disposal.

**6.4 Reference to other sections**

For disposal see section 13.

---

**7. HANDLING AND STORAGE****7.1 Precautions for safe handling**

Normal measures for preventive fire protection.  
For precautions see section 2.2.

**7.2 Conditions for safe storage, including any incompatibilities**

Keep container tightly closed in a dry and well-ventilated place. Containers which are opened must be carefully resealed and kept upright to prevent leakage.

**7.3 Specific end use(s)**

Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

---

**8. EXPOSURE CONTROLS/PERSONAL PROTECTION****8.1 Control parameters****Components with workplace control parameters**

Contains no substances with occupational exposure limit values.

**8.2 Exposure controls****Appropriate engineering controls**

General industrial hygiene practice.

## Personal protective equipment

### Eye/face protection

Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

### Skin protection

Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

### Body Protection

Impervious clothing. The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

### Respiratory protection

Respiratory protection not required. For nuisance exposures use type OV/AG (US) or type ABEK (EU EN 14387) respirator cartridges. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

### Control of environmental exposure

Do not let product enter drains.

---

## 9. PHYSICAL AND CHEMICAL PROPERTIES

### 9.1 Information on basic physical and chemical properties

|   |                             |
|---|-----------------------------|
| a) Appearance                                   | Form: liquid                |
| b) Odour  | no data available           |
| c) Odour Threshold                              | no data available           |
| d) pH   | no data available           |
| e) Melting point/freezing point                 | no data available           |
| f) Initial boiling point and boiling range      | 76 °C (169 °F)              |
| g) Flash point                                  | no data available           |
| h) Evaporation rate                             | no data available           |
| i) Flammability (solid, gas)                    | no data available           |
| j) Upper/lower flammability or explosive limits | no data available           |
| k) Vapour pressure                              | no data available           |
| l) Vapour density                               | no data available           |
| m) Relative density                             | 1.787 g/mL at 25 °C (77 °F) |
| n) Water solubility                             | no data available           |
| o) Partition coefficient: n-octanol/water       | no data available           |
| p) Auto-ignition temperature                    | no data available           |
| q) Decomposition temperature                    | no data available           |
| r) Viscosity                                    | no data available           |
| s) Explosive properties                         | no data available           |
| t) Oxidizing properties                         | no data available           |

## 9.2 Other safety information

no data available

---

## 10. STABILITY AND REACTIVITY

### 10.1 Reactivity

no data available

### 10.2 Chemical stability

Stable under recommended storage conditions.

### 10.3 Possibility of hazardous reactions

no data available

### 10.4 Conditions to avoid

no data available

### 10.5 Incompatible materials

Strong oxidizing agents

### 10.6 Hazardous decomposition products

Other decomposition products - no data available

In the event of fire: see section 5

---

## 11. TOXICOLOGICAL INFORMATION

### 11.1 Information on toxicological effects

#### Acute toxicity

no data available

Inhalation: no data available

Dermal: no data available

no data available

#### Skin corrosion/irritation

no data available

#### Serious eye damage/eye irritation

no data available

#### Respiratory or skin sensitisation

no data available

#### Germ cell mutagenicity

no data available

#### Carcinogenicity

| Organization | Classification  |
|--------------|---|
| IARC:        | No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC. |
| ACGIH:       | No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.            |
| NTP:         | No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.                 |
| OSHA:        | No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.             |

#### Reproductive toxicity

no data available

no data available

#### Specific target organ toxicity - single exposure

no data available

**Specific target organ toxicity - repeated exposure**

no data available

**Aspiration hazard**

no data available

**Additional Information**

RTECS: Not available

---

**12. ECOLOGICAL INFORMATION****12.1 Toxicity**

no data available

**12.2 Persistence and degradability**

no data available

**12.3 Bioaccumulative potential**

no data available

**12.4 Mobility in soil**

no data available

**12.5 Results of PBT and vPvB assessment**

PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

**12.6 Other adverse effects**

no data available

---

**13. DISPOSAL CONSIDERATIONS****13.1 Waste treatment methods****Product**

Offer surplus and non-recyclable solutions to a licensed disposal company.

**Contaminated packaging**

Dispose of as unused product.

---

**14. TRANSPORT INFORMATION****DOT (US)**

Not dangerous goods

**IMDG**

Not dangerous goods

**IATA**

Not dangerous goods

---

**15. REGULATORY INFORMATION****SARA 302 Components**

SARA 302: No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

**SARA 313 Components**

SARA 313: This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

**SARA 311/312 Hazards**

No SARA Hazards

**Massachusetts Right To Know Components**

No components are subject to the Massachusetts Right to Know Act.

**Pennsylvania Right To Know Components**

Perfluoro(methylcyclohexane)

CAS-No.  
355-02-2

Revision Date

## New Jersey Right To Know Components

Perfluoro(methylcyclohexane)

CAS-No.  
355-02-2

Revision Date

## California Prop. 65 Components

This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

---

## 16. OTHER INFORMATION

|                        |          |
|------------------------|----------|
| <b>HMIS Rating</b>     | <b>#</b> |
| Health hazard:         | 0        |
| Chronic Health Hazard: |          |
| Flammability:          | 0        |
| Physical Hazard        | 0        |

|                    |          |
|--------------------|----------|
| <b>NFPA Rating</b> | <b>#</b> |
| Health hazard:     | 0        |
| Fire Hazard:       | 0        |
| Reactivity Hazard: | 0        |

### Further information

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The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See Sigma-Aldrich Website and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

### Preparation Information

Sigma-Aldrich Corporation  
Product Safety – Americas Region  
1-800-521-8956

Version: 5.2

Revision Date: 06/25/2014

Print Date: 11/20/2014

## SAFETY DATA SHEET

Version 4.3  
Revision Date 07/02/2014  
Print Date 11/20/2014

### 1. PRODUCT AND COMPANY IDENTIFICATION

#### 1.1 Product identifiers

Product name : Perfluoro-1,3-dimethylcyclohexane

Product Number : 282316

Brand : Aldrich

CAS-No. : 335-27-3

#### 1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses : Laboratory chemicals, Manufacture of substances

#### 1.3 Details of the supplier of the safety data sheet

Company : Sigma-Aldrich  
3050 Spruce Street  
SAINT LOUIS MO 63103  
USA

Telephone : +1 800-325-5832

Fax : +1 800-325-5052

#### 1.4 Emergency telephone number

Emergency Phone # : (314) 776-6555

### 2. HAZARDS IDENTIFICATION

#### 2.1 Classification of the substance or mixture

##### GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)

Skin irritation (Category 2), H315

Eye irritation (Category 2A), H319

Specific target organ toxicity - single exposure (Category 3), Respiratory system, H335

For the full text of the H-Statements mentioned in this Section, see Section 16.

#### 2.2 GHS Label elements, including precautionary statements

Pictogram



Signal word

Warning

Hazard statement(s)

H315

Causes skin irritation.

H319

Causes serious eye irritation.

H335

May cause respiratory irritation.

Precautionary statement(s)

P261

Avoid breathing dust/ fume/ gas/ mist/ vapours/ spray.

P264

Wash skin thoroughly after handling.

P271

Use only outdoors or in a well-ventilated area.

P280

Wear protective gloves/ eye protection/ face protection.

P302 + P352

IF ON SKIN: Wash with plenty of soap and water.

P304 + P340

IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing.

P305 + P351 + P338

IF IN EYES: Rinse cautiously with water for several minutes. Remove

|             |   |
|-------------|---|
| P312        | contact lenses, if present and easy to do. Continue rinsing.                |
| P321        | Call a POISON CENTER or doctor/ physician if you feel unwell.               |
| P332 + P313 | Specific treatment (see supplemental first aid instructions on this label). |
| P337 + P313 | If skin irritation occurs: Get medical advice/ attention.                   |
| P362        | If eye irritation persists: Get medical advice/ attention.                  |
| P403 + P233 | Take off contaminated clothing and wash before reuse.                       |
| P405        | Store in a well-ventilated place. Keep container tightly closed.            |
| P501        | Store locked up.  |
|             | Dispose of contents/ container to an approved waste disposal plant.         |

## 2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none

## 3. COMPOSITION/INFORMATION ON INGREDIENTS

### 3.1 Substances

|                  |   |
|------------------|---|
| Synonyms         | Hexadecafluoro-1,3-dimethylcyclohexane (cis+trans)<br>Hexadecafluoro-1,3-dimethylcyclohexane Decafluoro-1,3-bis(trifluoromethyl)cyclohexane |
| Formula          | C <sub>8</sub> F <sub>16</sub>  |
| Molecular Weight | 400.06 g/mol  |
| CAS-No.          | 335-27-3  |
| EC-No.           | 206-386-9   |

### Hazardous Components

| Component   | Classification   | Concentration |
|---|--|---------------|
| <b>1,1,2,2,3,3,4,5,5,6-Decafluoro-4,6-bis(trifluoromethyl)cyclohexane</b> | Skin Irrit. 2; Eye Irrit. 2A;<br>STOT SE 3; H315, H319, H335 | -             |

For the full text of the H-Statements mentioned in this Section, see Section 16.

## 4. FIRST AID MEASURES

### 4.1 Description of first aid measures

#### General advice

Consult a physician. Show this safety data sheet to the doctor in attendance. Move out of dangerous area.

#### If inhaled

If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

#### In case of skin contact

Wash off with soap and plenty of water. Consult a physician.

#### In case of eye contact

Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.

#### If swallowed

Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

### 4.2 Most important symptoms and effects, both acute and delayed

The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

### 4.3 Indication of any immediate medical attention and special treatment needed

no data available

## 5. FIREFIGHTING MEASURES

### 5.1 Extinguishing media

#### Suitable extinguishing media

Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

## **5.2 Special hazards arising from the substance or mixture**

Carbon oxides, Hydrogen fluoride

## **5.3 Advice for firefighters**

Wear self contained breathing apparatus for fire fighting if necessary.

## **5.4 Further information**

no data available

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## **6. ACCIDENTAL RELEASE MEASURES**

### **6.1 Personal precautions, protective equipment and emergency procedures**

Use personal protective equipment. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Evacuate personnel to safe areas.

For personal protection see section 8.

### **6.2 Environmental precautions**

Do not let product enter drains.

### **6.3 Methods and materials for containment and cleaning up**

Soak up with inert absorbent material and dispose of as hazardous waste. Keep in suitable, closed containers for disposal.

### **6.4 Reference to other sections**

For disposal see section 13.

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## **7. HANDLING AND STORAGE**

### **7.1 Precautions for safe handling**

Avoid contact with skin and eyes. Avoid inhalation of vapour or mist.

Normal measures for preventive fire protection.

For precautions see section 2.2.

### **7.2 Conditions for safe storage, including any incompatibilities**

Keep container tightly closed in a dry and well-ventilated place. Containers which are opened must be carefully resealed and kept upright to prevent leakage.

### **7.3 Specific end use(s)**

Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

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## **8. EXPOSURE CONTROLS/PERSONAL PROTECTION**

### **8.1 Control parameters**

#### **Components with workplace control parameters**

Contains no substances with occupational exposure limit values.

### **8.2 Exposure controls**

#### **Appropriate engineering controls**

Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

#### **Personal protective equipment**

##### **Eye/face protection**

Safety glasses with side-shields conforming to EN166 Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

##### **Skin protection**

Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

##### **Body Protection**

impervious clothing, The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.



**Respiratory protection**

Where risk assessment shows air-purifying respirators are appropriate use a full-face respirator with multi-purpose combination (US) or type ABEK (EN 14387) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

**Control of environmental exposure**

Do not let product enter drains.

---

**9. PHYSICAL AND CHEMICAL PROPERTIES****9.1 Information on basic physical and chemical properties**

|   |   |
|---|---|
| a) Appearance                                   | Form: clear, liquid<br>Colour: light yellow |
| b) Odour  | no data available                           |
| c) Odour Threshold                              | no data available                           |
| d) pH   | no data available                           |
| e) Melting point/freezing point                 | Melting point/range: -55 °C (-67 °F) - lit. |
| f) Initial boiling point and boiling range      | 101 - 102 °C (214 - 216 °F) - lit.          |
| g) Flash point                                  | no data available                           |
| h) Evaporation rate                             | no data available                           |
| i) Flammability (solid, gas)                    | no data available                           |
| j) Upper/lower flammability or explosive limits | no data available                           |
| k) Vapour pressure                              | no data available                           |
| l) Vapour density                               | 13.81 - (Air = 1.0)                         |
| m) Relative density                             | 1.828 g/cm <sup>3</sup> at 25 °C (77 °F)    |
| n) Water solubility                             | no data available                           |
| o) Partition coefficient: n-octanol/water       | no data available                           |
| p) Auto-ignition temperature                    | no data available                           |
| q) Decomposition temperature                    | no data available                           |
| r) Viscosity                                    | no data available                           |
| s) Explosive properties                         | no data available                           |
| t) Oxidizing properties                         | no data available                           |

**9.2 Other safety information**

|                         |                     |
|-------------------------|---------------------|
| Relative vapour density | 13.81 - (Air = 1.0) |
|-------------------------|---------------------|

---

**10. STABILITY AND REACTIVITY****10.1 Reactivity**

no data available

**10.2 Chemical stability**

Stable under recommended storage conditions.

**10.3 Possibility of hazardous reactions**

no data available

#### 10.4 Conditions to avoid

no data available

#### 10.5 Incompatible materials

Strong oxidizing agents

#### 10.6 Hazardous decomposition products

Other decomposition products - no data available

In the event of fire: see section 5

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### 11. TOXICOLOGICAL INFORMATION

#### 11.1 Information on toxicological effects

##### Acute toxicity

no data available

Dermal: no data available

no data available

##### Skin corrosion/irritation

no data available

##### Serious eye damage/eye irritation

no data available

##### Respiratory or skin sensitisation

no data available

##### Germ cell mutagenicity

no data available

##### Carcinogenicity

| Organization | Classification |
|--------------|----------------|
|--------------|----------------|

|       |   |
|-------|---|
| IARC: | No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC. |
|-------|---|

|        |  |
|--------|--|
| ACGIH: | No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH. |
|--------|--|

|      |   |
|------|---|
| NTP: | No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP. |
|------|---|

|       |   |
|-------|---|
| OSHA: | No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA. |
|-------|---|

##### Reproductive toxicity

no data available

no data available

##### Specific target organ toxicity - single exposure

Inhalation - May cause respiratory irritation.

##### Specific target organ toxicity - repeated exposure

no data available

##### Aspiration hazard

no data available

##### Additional Information

RTECS: Not available

To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

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### 12. ECOLOGICAL INFORMATION

#### 12.1 Toxicity

no data available

**12.2 Persistence and degradability**

no data available

**12.3 Bioaccumulative potential**

no data available

**12.4 Mobility in soil**

no data available

**12.5 Results of PBT and vPvB assessment**

PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

**12.6 Other adverse effects**

no data available

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**13. DISPOSAL CONSIDERATIONS****13.1 Waste treatment methods****Product**

Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material.

**Contaminated packaging**

Dispose of as unused product.

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**14. TRANSPORT INFORMATION****DOT (US)**

Not dangerous goods

**IMDG**

Not dangerous goods

**IATA**

Not dangerous goods

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**15. REGULATORY INFORMATION****SARA 302 Components**

SARA 302: No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

**SARA 313 Components**

SARA 313: This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

**SARA 311/312 Hazards**

Acute Health Hazard

**Massachusetts Right To Know Components**

No components are subject to the Massachusetts Right to Know Act.

**Pennsylvania Right To Know Components**

|   | CAS-No.  | Revision Date |
|---|----------|---------------|
| 1,1,2,2,3,3,4,5,5,6-Decafluoro-4,6<br>bis(trifluoromethyl)cyclohexane | 335-27-3 |               |

**New Jersey Right To Know Components**

|   | CAS-No.  | Revision Date |
|---|----------|---------------|
| 1,1,2,2,3,3,4,5,5,6-Decafluoro-4,6<br>bis(trifluoromethyl)cyclohexane | 335-27-3 |               |

**California Prop. 65 Components**

This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

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## 16. OTHER INFORMATION

### Full text of H-Statements referred to under sections 2 and 3.

|             |  |
|-------------|--|
| Eye Irrit.  | Eye irritation                                   |
| H315        | Causes skin irritation.                          |
| H319        | Causes serious eye irritation.                   |
| H335        | May cause respiratory irritation.                |
| Skin Irrit. | Skin irritation                                  |
| STOT SE     | Specific target organ toxicity - single exposure |

### HMIS Rating

|                        |   |
|------------------------|---|
| Health hazard:         | 2 |
| Chronic Health Hazard: |   |
| Flammability:          | 0 |
| Physical Hazard        | 0 |

### NFPA Rating

|                    |   |
|--------------------|---|
| Health hazard:     | 2 |
| Fire Hazard:       | 0 |
| Reactivity Hazard: | 0 |

### Further information

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The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See Sigma-Aldrich Website and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

### Preparation Information

Sigma-Aldrich Corporation  
Product Safety – Americas Region  
1-800-521-8956

Version: 4.3

Revision Date: 07/02/2014

Print Date: 11/20/2014

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