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EMSL Order ID.: 361501870A
Sample(s) Received: 10/1/2015
Date of Reporting: 10/15/2015Rev1
Date Printed: 10/16/2015
Reported By: M. Zacharkow
Email: rbdyechem@rediffmail.com

- Laboratory Report -
Explosibility of Dust Clouds

Project: Holi Color Powder/Gulal

Procurement of Samples and Analytical Overview:

The material for analysis (one bulk sample) arrived at EMSL Analytical’s corporate laboratory in Cinnaminson, NJ on October 1, 2015. The package arrived in satisfactory condition with no evidence of damage to the contents. The data reported herein has been obtained using the following equipment and methodologies.

Methods & Equipment: OSHA ID201SG- Explosibility and Combustibility Parameters
Directive CPL 03-00-008- Combustible Dust National Emphasis Program
ASTM E1226-12- Standard Test Method for Explosibility of Dust Clouds
ASTM D422-98 (Mod)-Standard Test Method for Particle-Size Analysis of Soils

20-L Siwek chamber-picture below
Mechanical Sieve system



10/16/15: Revision 1 revises report 361501870 reported on 10/15/15. This report includes changes to Go/No Go testing procedure as requested by the client and updated results.

Analyzed by:

Michael Zacharkow
Laboratory Technician

October 15, 2015

Date

Reviewed/Approved:

Jian Hu, Ph.D.
Senior Materials Scientist

October 15, 2015

Date



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Results and Discussion:

- Go/No Go screening test was conducted using 2.5kJ ignition source as requested by the client. The criterion used for a “Go” qualifier is 1-bar explosion overpressure after accounting for the influence of the 2.5 kJ ignition source.

Customer Sample ID	1	
Sample Description	Holi Color Powder / Glulal	
EMSL Sample ID	361501870-0001	
Parameter	Value	Units
Sample Weight	310.01	g
Sieve (40 mesh Retained)	51.65	%wt
Sieve (40 mesh Passing)	48.35	%wt
Moisture (as received)	18.16	%wt
Combustible Material (see Note 1)	78.53	%wt
Combustible Dust (see Note 2)	37.97	%wt

According to OSHA directive CPL 03-00-008, sieving was performed on the “as received” material.

Per ASTM E1226-12 recommendations, material that contains > 5% moisture should be dried out prior to testing. Moisture in the dust particles raises the ignition temperature of the dust because of the heat absorbed during heating and vaporization of the moisture; therefore, the dust may present a lower explosion propensity.

As per client request the sample was tested “as received from client” and was not dried, sieved, or altered in any way prior to testing. Per client request, 2.5kJ ignition source was used instead of 5.0kJ or greater ignition source as specified in the OSHA directive CPL 03-00-008 and ASTM E1226. Using 2.5kJ ignition source may lead to false negative result. The sample was determined to be “non-explosible” in dust form (“No GO”) under the above conditions specified by the client.

Detailed Explosion Severity Results:

Sample ID	500 g/m ³	1000 g/m ³	2000 g/m ³
	Explosion overpressure [bar]	Explosion overpressure [bar]	Explosion overpressure [bar]
1	0.2	0.0	0.1

A material classified "not explosible" is not necessarily non-combustible. The same material when exposed to different conditions, such as elevated temperatures, external heat flux, presence of flammable vapors, size reduction or moisture, may undergo smoldering, flaming or deflagrative combustion either as a dust cloud or as layer. Additional analysis should be considered where adverse process or storage conditions exist or where there is a basis to believe the material has the potential to self-heat.



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Note 1: % Combustible Material is defined as % Ash Content (determined as weight loss at ashing/pyrolyzing the sample for 1 h at 600°C); defined in OSHA ID201SG-.

Note 2: % Combustible Dust = (% pass 40 mesh) * (% Combustible Material); defined in OSHA ID201SG-

Additional data-Particle size analysis:

Customer Sample ID	1
Sample Description	Holi Color Powder / Glulal
EMSL Sample ID	361501870-0001
Particle Size Range	wt% in the Size Range
2" - 1"	0.00
1" - ¾"	0.00
¾" - 3/8"	0.00
3/8" - 4.75 mm	0.00
4.75 mm - 2.00 mm	0.00
2.00 mm - 425 µm	51.65
425 µm - 75 µm	6.62
<75 µm	41.74



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Descriptions and Definitions:

The P_{max} is the average maximum pressure (above pressure in the vessel at the time of ignition) reached during the course of a deflagration for the optimum concentration of the dust tested. P_{max} is determined by a series of tests over a large range of concentrations

The $(dP/dt)_{max}$ is the average maximum value for the rate of pressure increase per unit time reached during the course of a deflagration for the optimum concentration of dust tested. It is determined by a series of tests over a large range of concentrations.

The **Deflagration Index, K_{St}** is the average maximum dP/dt normalized to a 1.0- m^3 volume. It is measured at the optimum dust concentration. K_{St} is defined in accordance with the following cubic relationship:

$$K_{St} = (dP/dt)_{max} \times V^{1/3}$$

The following is a partial listing of definitions based on NFPA standards and 29 CFR 1910.399, the definitions provision of Subpart S—Electrical, that relate to combustible dust.

- A. **Class II locations.** Class II locations are those that are hazardous because of the presence of combustible dust. The following are Class II locations where the combustible dust atmospheres are present:

Group E. Atmospheres containing combustible metal dusts, including aluminum, magnesium, and their commercial alloys, and other combustible dusts whose particle size, abrasiveness, and conductivity present similar hazards in the use of electrical equipment.

Group F. Atmospheres containing combustible carbonaceous dusts that have more than 8 percent total entrapped volatiles (see ASTM D 3175, *Standard Test Method for Volatile Matter in the Analysis Sample of Coal and Coke*, for coal and coke dusts) or that have been sensitized by other materials so that they present an explosion hazard. Coal, carbon black, charcoal, and coke dusts are examples of carbonaceous dusts.

Group G. Atmosphere containing other combustible dusts, including flour, grain, wood flour, plastic and chemicals.

- B. **Combustible dust.** A combustible particulate solid that presents a fire or deflagration hazard when suspended in air or some other oxidizing medium over a range of concentrations, regardless of particle size or shape.
- C. **Combustible Particulate Solid.** Any combustible solid material composed of distinct particles or pieces, regardless of size, shape, or chemical composition.
- D. **Hybrid Mixture.** A mixture of a flammable gas with either a combustible dust or a combustible mist.
- E. **Deflagration.** Propagation of a combustion zone at a speed that is less than the speed of sound in the unreacted medium.
- F. **Deflagration Isolation.** Method employing equipment and procedures that interrupts the propagation of a deflagration of a flame front, past a predetermined point.
- G. **Deflagration Suppression.** The technique of detecting and arresting combustion in a confined space while the combustion is still in its incipient stage, thus preventing the development of pressures that could result in an explosion.
- H. **Detonation.** Propagation of a combustion zone at a velocity that is greater than the speed of sound in the unreacted medium.
- I. **Dust-ignitionproof.** Equipment enclosed in a manner that excludes dusts and does not permit arcs, sparks, or heat otherwise generated or liberated inside of the enclosure to cause ignition of exterior accumulations or atmospheric suspensions of a specified dust on or in the vicinity of the enclosure.
- J. **Dusttight.** Enclosures constructed so that dust will not enter under specified test conditions.



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- K. **Explosion.** The bursting or rupture of an enclosure or a container due to the development of internal pressure from deflagration.
- L. **Minimum Explosible Concentration (MEC).** The minimum concentration of combustible dust suspended in air, measured in mass per unit volume that will support a deflagration.

Following conditions may also indicate that a potential dust deflagration, other fire, or explosion hazard exists:

- a) **Plant History of Fires:** The plant has a history of fires involving combustible dusts.
- b) **Material Safety Data Sheets (MSDS):** The MSDS may indicate that a particular dust is combustible and can cause explosions, deflagrations, or other fires. However, do not use MSDSs as a sole source of information because this information is often excluded from MSDSs.
- c) **Dust Accumulations:** Annex D of NFPA 654 contains guidance on dust layer characterization and precautions. It indicates that immediate cleaning is warranted whenever a dust layer of 1/32- inch thickness accumulates over a surface area of at least 5% of the floor area of the facility or any given room. The 5% factor should not be used if the floor area exceeds 20,000 ft², in which case a 1,000 ft² layer of dust is the upper limit. Accumulations on overhead beams, joists, ducts, the tops of equipment, and other surfaces should be included when determining the dust coverage area. Even vertical surfaces should be included if the dust is adhering to them. Rough calculations show that the available surface area of bar joists is approximately 5 % of the floor area and the equivalent surface area for steel beams can be as high as 10%. The material in Annex D is an idealized approach based on certain assumptions, including uniformity of the dust layer covering the surfaces, a bulk density of 75 lb/ ft³, a dust concentration of 0.35 oz/ ft³, and a dust cloud height of 10 ft. Additionally, FM Data Sheet 7-76 contains a formula to determine the dust thickness that may create an explosion hazard in a room, when some of these variables differ.
- d) Observe areas of the plant for accumulations of hazardous levels of dust (for example, greater than 1/32 of an inch, which is approximately equal to the thickness of a typical paper clip). Likely areas of dust accumulations within a plant are:
- Structural members
 - Conduits and pipe racks
 - Cable trays
 - Floors
 - Above ceiling
 - On and around equipment (leaks around dust collectors and ductwork)
- e) If potential combustible dust hazards are found, dust samples must be safely collected.
- “High spaces” such as roof beams, open web beams, tops of pipes and ductwork, and other horizontal surfaces located as high in the overhead as possible. Note: These are the preferred locations; however, if a means of safe access is not available, sample(s) should not be collected
 - Equipment and floors where dust has accumulated
 - The interior (i.e., bins and/or bags) of a dust collector
 - Within ductwork

(From OSHA Directive No. CPL-03-00-008)



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Additional Reference Information:

Hazardous (classified) locations.

This section covers the requirements for electric equipment and wiring in locations which are classified depending on the properties of the flammable vapors, liquids or gases, or combustible dusts or fibers which may be present therein and the likelihood that a flammable or combustible concentration or quantity is present. Hazardous (classified) locations may be found in occupancies such as, but not limited to, the following: aircraft hangars, gasoline dispensing and service stations, bulk storage plants for gasoline or other volatile flammable liquids, paint-finishing process plants, health care facilities, agricultural or other facilities where excessive combustible dusts may be present, marinas, boat yards, and petroleum and chemical processing plants. Each room, section or area shall be considered individually in determining its classification. These hazardous (classified) locations are assigned six designations as follows:

Class I, Division 1

Class I, Division 2

Class II, Division 1

Class II, Division 2

Class III, Division 1

Class III, Division 2

Class I locations. Class I locations are those in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures. Class I locations include the following:

(i) Class I, Division 1. A Class I, Division 1 location is a location: (a) in which hazardous concentrations of flammable gases or vapors may exist under normal operating conditions; or (b) in which hazardous concentrations of such gases or vapors may exist frequently because of repair or maintenance operations or because of leakage; or (c) in which breakdown or faulty operation of equipment or processes might release hazardous concentrations of flammable gases or vapors, and might also cause simultaneous failure of electric equipment.

Note: This classification usually includes locations where volatile flammable liquids or liquefied flammable gases are transferred from one container to another; interiors of spray booths and areas in the vicinity of spraying and painting operations where volatile flammable solvents are used; locations containing open tanks or vats of volatile flammable liquids; drying rooms or compartments for the evaporation of flammable solvents; locations containing fat and oil extraction equipment using volatile flammable solvents; portions of cleaning and dyeing plants where flammable liquids are used; gas generator rooms and other portions of gas manufacturing plants where flammable gas may escape; inadequately ventilated pump rooms for flammable gas or for volatile flammable liquids; the interiors of refrigerators and freezers in which volatile flammable materials are stored in open, lightly stoppered, or easily ruptured containers; and all other locations where ignitable concentrations of flammable vapors or gases are likely to occur in the course of normal operations.

(ii) Class I, Division 2. A Class I, Division 2 location is a location: (a) in which volatile flammable liquids or flammable gases are handled, processed, or used, but in which the hazardous liquids, vapors, or gases will normally be confined within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or systems, or in case of abnormal operation of equipment; or (b) in which hazardous concentrations of gases or vapors are normally prevented by positive mechanical ventilation, and which might become hazardous through failure or abnormal operations of the ventilating equipment; or (c) that is adjacent to a Class I, Division 1 location, and to which hazardous concentrations of gases or vapors might occasionally be communicated unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided.

Note: This classification usually includes locations where volatile flammable liquids or flammable gases or vapors are used, but which would become hazardous only in case of an accident or of some unusual operating condition. The quantity of flammable material that might escape in case of accident, the adequacy of ventilating equipment, the total area involved, and the record of the industry or business with respect to explosions or fires are all factors that merit consideration in determining the classification and extent of each location.



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Piping without valves, checks, meters, and similar devices would not ordinarily introduce a hazardous condition even though used for flammable liquids or gases. Locations used for the storage of flammable liquids or a liquefied or compressed gases in sealed containers would not normally be considered hazardous unless also subject to other hazardous conditions.

Electrical conduits and their associated enclosures separated from process fluids by a single seal or barrier are classed as a Division 2 location if the outside of the conduit and enclosures is a non-hazardous location.

Class II locations: Class II locations are those that are hazardous because of the presence of combustible dust. Class II locations include the following:

(i) Class II, Division 1. A Class II, Division 1 location is a location: (a) In which combustible dust is or may be in suspension in the air under normal operating conditions, in quantities sufficient to produce explosive or ignitable mixtures; or (b) where mechanical failure or abnormal operation of machinery or equipment might cause such explosive or ignitable mixtures to be produced, and might also provide a source of ignition through simultaneous failure of electric equipment, operation of protection devices, or from other causes, or (c) in which combustible dusts of an electrically conductive nature may be present.

Note: This classification may include areas of grain handling and processing plants, starch plants, sugar-pulverizing plants, malting plants, hay-grinding plants, coal pulverizing plants, areas where metal dusts and powders are produced or processed, and other similar locations which contain dust producing machinery and equipment (except where the equipment is dust-tight or vented to the outside). These areas would have combustible dust in the air, under normal operating conditions, in quantities sufficient to produce explosive or ignitable mixtures. Combustible dusts which are electrically nonconductive include dusts produced in the handling and processing of grain and grain products, pulverized sugar and cocoa, dried egg and milk powders, pulverized spices, starch and pastes, potato and wood flour, oil meal from beans and seed, dried hay, and other organic materials which may produce combustible dusts when processed or handled. Dusts containing magnesium or aluminum are particularly hazardous and the use of extreme caution is necessary to avoid ignition and explosion.

(ii) Class II, Division 2. A Class II, Division 2 location is a location in which: (a) combustible dust will not normally be in suspension in the air in quantities sufficient to produce explosive or ignitable mixtures, and dust accumulations are normally insufficient to interfere with the normal operation of electrical equipment or other apparatus; or (b) dust may be in suspension in the air as a result of infrequent malfunctioning of handling or processing equipment, and dust accumulations resulting there from may be ignitable by abnormal operation or failure of electrical equipment or other apparatus.

Note: This classification includes locations where dangerous concentrations of suspended dust would not be likely but where dust accumulations might form on or in the vicinity of electric equipment. These areas may contain equipment from which appreciable quantities of dust would escape under abnormal operating conditions or be adjacent to a Class II Division 1 location, as described above, into which an explosive or ignitable concentration of dust may be put into suspension under abnormal operating conditions.

Class III locations. Class III locations are those that are hazardous because of the presence of easily ignitable fibers or flyings but in which such fibers or flyings are not likely to be in suspension in the air in quantities sufficient to produce ignitable mixtures. Class III locations include the following:

(i) Class III, Division 1. A Class III, Division 1 location is a location in which easily ignitable fibers or materials producing combustible flyings are handled, manufactured, or used.

Note: Such locations usually include some parts of rayon, cotton, and other textile mills; combustible fiber manufacturing and processing plants; cotton gins and cotton-seed mills; flax-processing plants; clothing manufacturing plants; woodworking plants, and establishments; and industries involving similar hazardous processes or conditions.

Easily ignitable fibers and flyings include rayon, cotton (including cotton linters and cotton waste), sisal or henequen, istle, jute, hemp, tow, cocoa fiber, oakum, baled waste kapok, Spanish moss, excelsior, and other materials of similar nature.

(ii) Class III, Division 2. A Class III, Division 2 location is a location in which easily ignitable fibers are stored or handled, except in process of manufacture.



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Appendix E, Sub section 5, Maximum Normalized Rate of Pressure Rise

<i>Dust Explosion Class</i>	<i>K_{st} (bar.m/s)</i>	<i>Characteristic</i>
St 0	0	No Explosion
St 1	>0 and ≤200	Weak Explosion
St 2	>200 and ≤300	Strong Explosion
St 3	>300	Very Strong Explosion

Table from OSHA CPL 03-00-008: Explosion class determination from the maximum normalized rate of explosion.

(from **PART 1910 – Occupational Safety and Health Standards**)

Subpart S – Electrical Design Safety Standards for Electrical Systems)



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Important Terms, Conditions, and Limitations:

Sample Retention: Samples analyzed by EMSL will be retained for 60 days after analysis date. Storage beyond this period is available for a fee with written request prior to the initial 30 day period. Samples containing hazardous/toxic substances which require special handling may be returned to the client immediately. EMSL reserves the right to charge a sample disposal or return shipping fee.

Change Orders and Cancellation: All changes in the scope of work or turnaround time requested by the client after sample acceptance must be made in writing and confirmed in writing by EMSL. If requested changes result in a change in cost the client must accept payment responsibility. In the event work is cancelled by a client, EMSL will complete work in progress and invoice for work completed to the point of cancellation notice. EMSL is not responsible for holding times that are exceeded due to such changes.

Warranty: EMSL warrants to its clients that all services provided hereunder shall be performed in accordance with established and recognized analytical testing procedures, when available. The foregoing express warranty is exclusive and is given in lieu of all other warranties, expressed or implied. EMSL disclaims any other warranties, express or implied, including a warranty of fitness for particular purpose and warranty of merchantability.

Limits of Liability: In no event shall EMSL be liable for indirect, special, consequential, or incidental damages, including, but not limited to, damages for loss of profit or goodwill regardless of the negligence (either sole or concurrent) of EMSL and whether EMSL has been informed of the possibility of such damages, arising out of or in connection with EMSL's services thereunder or the delivery, use, reliance upon or interpretation of test results by client or any third party. We accept no legal responsibility for the purposes for which the client uses the test results. EMSL will not be held responsible for the improper selection of sampling devices even if we supply the device to the user. The user of the sampling device has the sole responsibility to select the proper sampler and sampling conditions to insure that a valid sample is taken for analysis. Any resampling performed will be at the sole discretion of EMSL, the cost of which shall be limited to the reasonable value of the original sample delivery group (SDG) samples. In no event shall EMSL be liable to a client or any third party, whether based upon theories of tort, contract or any other legal or equitable theory, in excess of the amount paid to EMSL by client thereunder.

The data and other information contained in this report, as well as any accompanying documents, represent only the samples analyzed. They are reported upon the condition that they are not to be reproduced wholly or in part for advertising or other purposes without the written approval from the laboratory.