Dust Hazards in Wind Turbine Blade Repair

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October 12, 2021

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Meet the Presenter

Education:
B.S. Fire and Safety Engineering Technology
M.Eng. Advanced Safety Engineering and Management
PhD Candidate – Interdisciplinary Engineering
    Research topic – Dust Hazards in Wind Turbine Blade Processes

Certifications:
Certified Fire Protection Specialist – NFPA
Certified Fire and Explosion Investigator – NAFI
Certified Vehicle Fire Investigator – NAFI

Meet the Presenter

Current Employment:
President, Cross Fire and Safety
Assistant Professor, EKU Fire Protection and Safety Engineering Tech

Past Employment:
Director of Operations, Mortenson Energy Services
Director of Quality and EHS, Siemens Wind
Operations Manager, Siemens Wind
Consulting Engineer, FM Global

Why are we here

Siemens B53 Campaign

Previous dust explosion investigation

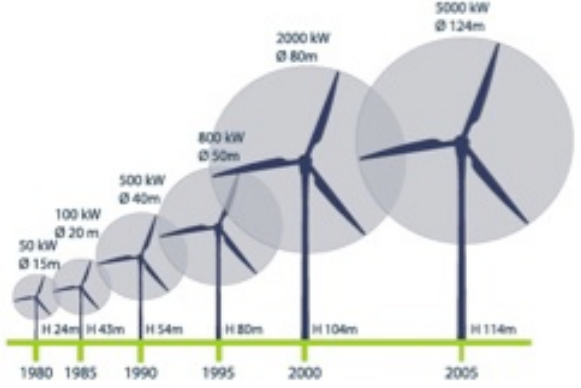
“New” guidance in NFPA

PhD Research topic

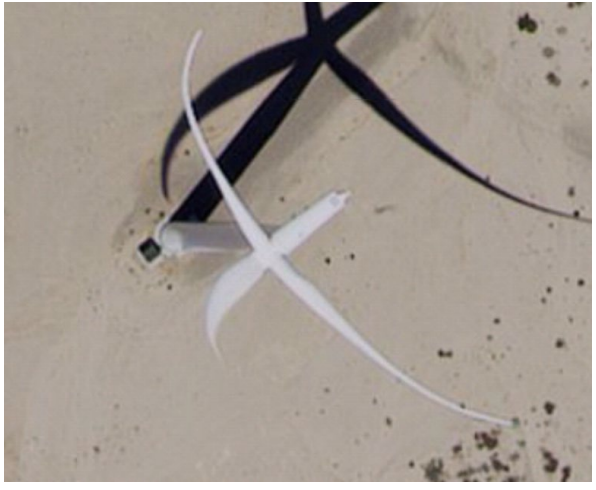
Source: https://www.youtube.com/watch?v=RZLRbVw3RnM

What’s behind the issue

Wind turbine blades are getting larger, challenging the engineering and manufacturing communities.



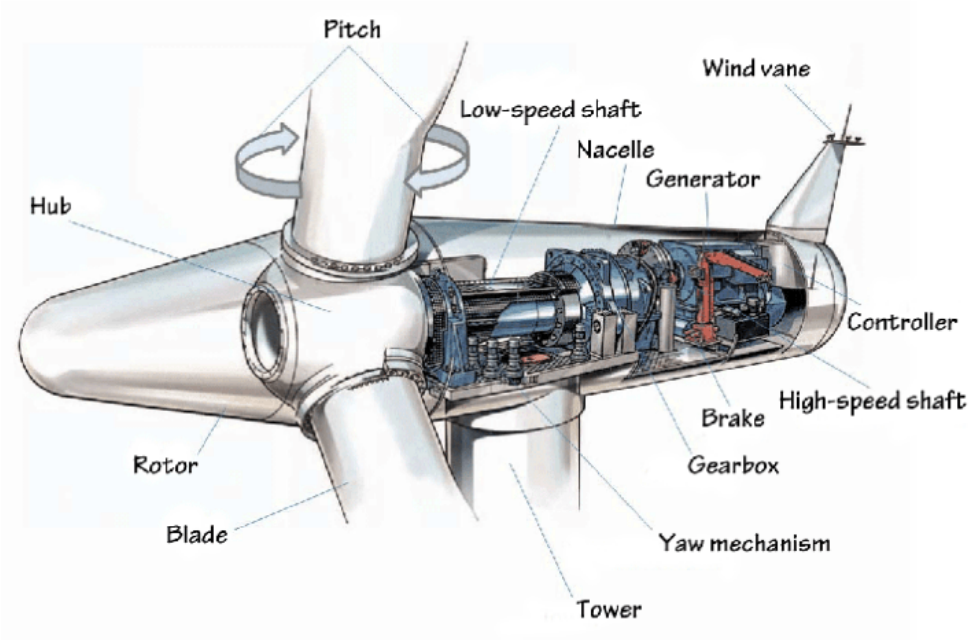
Turbine blades are made of mostly fiberglass or carbon fiber with a wood or foam core.



Issues in design, manufacturing, or operational parameters can require in situ repairs.

Wind Turbine Blade Repair Process – Blade Access

Diagram 2. The major components of a wind turbine



SOURCE: Center on Globalization, Governance, and Competitiveness, Duke University

Common Industry Approach

Internal blade repairs include the removal of material by grinding.

This grinding creates combustible/explosible dust.

Due to the environment this presents significant risk to workers and equipment

Additional hazards

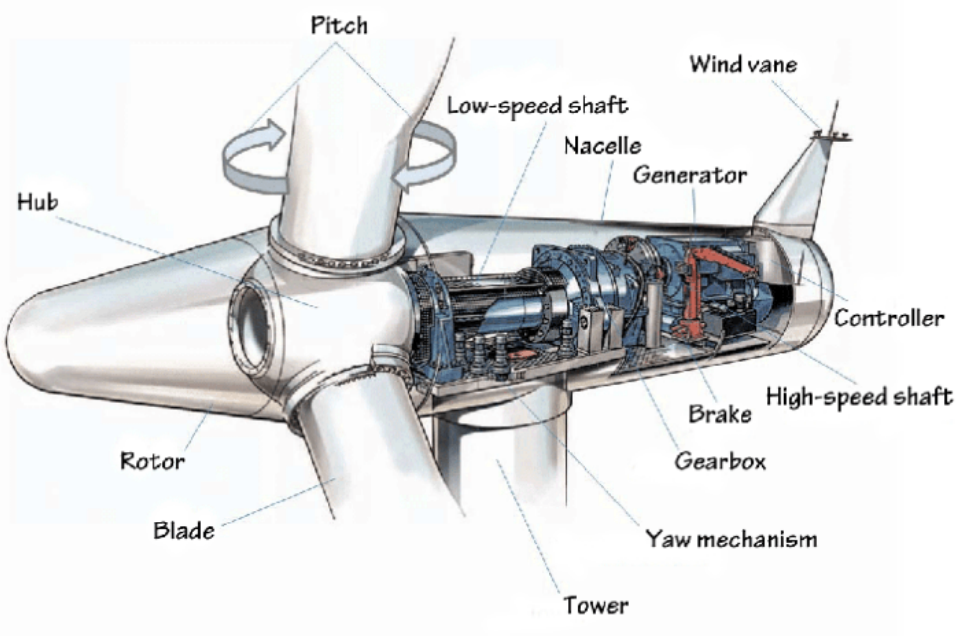
All of the work is 300’ above Grade – limited rescue

There are limited opportunities for overpressure ventilation

Excessive pressure may cause structural failure

Flash fire exposure is IDLH

Diagram 2. The major components of a wind turbine

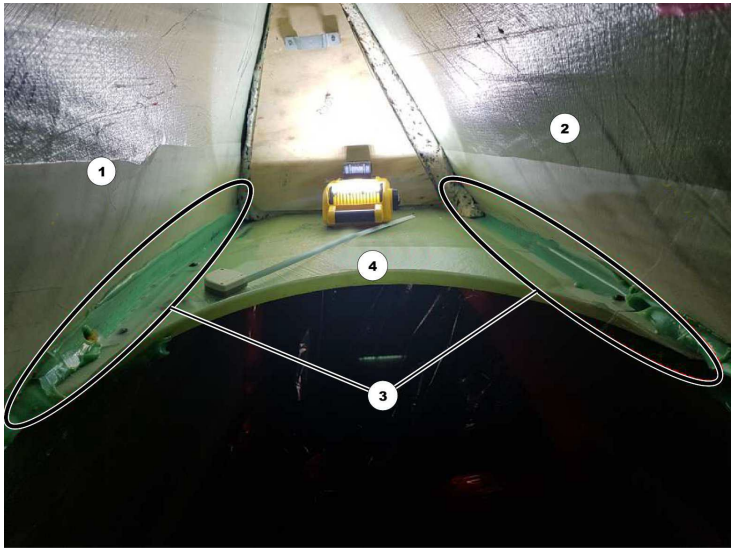


SOURCE: Center on Globalization, Governance, and Competitiveness, Duke University

Common Industry Approach

Technicians enter the space with the following tools:

- 4 or 7 inch angle grinder with standard abrasives or belt sander
- Shop vac with combustible container
- No bonding/grounding on plastic hoses
- No limits on dust accumulation or vacuum cleanout schedule
- Ventilation used during the process for confined space or heat concerns



Potential for Enforcement -

https://www.osha.gov/enforcement/directives/nep

UNITED STATES
DEPARTMENT OF LABOR

Occupational Safety and Health Administration

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Enforcement / Directives - NEP

Directives - NEP

National Emphasis Programs (NEPs) are temporary programs that focus OSHA's resources on particular hazards and high-hazard industries. Existing and potential new emphasis programs are evaluated using inspection data, injury and illness data, National Institute for Occupational Safety and Health (NIOSH) reports, peer-reviewed literature, analysis of inspection findings, and other available information sources.

Publication Date | Directive # | NEP | Regional LEP | State Plan Adoption | Advanced Search

Combustible Dust

- OSHA Instruction - CPL 03-00-008 - Combustible Dust National Emphasis Program (Reissued) - 03/11/2008 - PDF

Coronavirus (COVID-19)

- OSHA Direction - DIR 2021-03(CPL 03) - Revised National Emphasis Program – Coronavirus Disease 2019 (COVID-19) - 07/07/2021 - PDF

Hazardous Machinery

- OSHA Instruction - CPL 03-00-022 - National Emphasis Program on Amputations in Manufacturing Industries - 12/10/2019 - PDF

Potential for Enforcement -

https://www.osha.gov/sites/default/files/enforcement/directives/CPL_03-00-008.pdf

This has been OSHA's top compliance initiative since 2008

OSHA INSTRUCTION

U.S. DEPARTMENT OF LABOR — Occupational Safety and Health Administration

DIRECTIVE NUMBER: CPL 03-00-008	EFFECTIVE DATE: 3/11/08
SUBJECT: Combustible Dust National Emphasis Program (Reissued)	

****NOTE: As a result of the March 26, 2012, revision to OSHA's Hazard Communication Standard, minor changes {in brackets} were made to this directive on October 1, 2015. These changes do not impact this directive's enforcement policy.**

ABSTRACT

Purpose: This instruction contains policies and procedures for inspecting workplaces that create or handle combustible dusts. In some circumstances these dusts may cause a deflagration, other fires, or an explosion. These dusts include, but are not limited to:

- Metal dust such as aluminum and magnesium.
- Wood dust
- Coal and other carbon dusts.
- Plastic dust and additives
- Biosolids
- Other organic dust such as sugar, flour, paper, soap, and dried blood.
- Certain textile materials

Potential for Enforcement -

https://www.osha.gov/sites/default/files/enforcement/directives/CPL_03-00-008.pdf

In situations where the facility being inspected is not a grain handling facility, the lab results indicate that the dust is combustible, and the combustible dust accumulations not contained within dust control systems or other containers, such as storage bins, are extensive enough to pose a deflagration, explosion, or other fire hazard, then citations under 29 CFR 1910.22 (housekeeping) or, where appropriate, 29 CFR 1910.176(c) (housekeeping in storage areas) may generally be issued. Combustible dusts found in grain handling facilities are covered by 29 CFR 1910.272.

For workplaces not covered by 1910.272, but where combustible dust hazards exist within dust control systems or other containers, citations under section 5(a)(1) of the OSH Act (the General Duty Clause) may generally be issued for deflagration, other fire, or explosion hazards. National Fire Protection Association (NFPA) standards (listed in Appendix A of this directive) should be consulted to obtain evidence of hazard recognition and feasible abatement methods. Other standards are applicable to the combustible dust hazard. For example, if the workplace has a *Class II* location, then citations under 29 CFR 1910.307 may be issued to those employers having electrical equipment not meeting the standard's requirements.

Applicable NFPA Standards

NFPA 652, Standard on the Fundamentals of Combustible Dust.

NFPA 654, Standard for the prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids.

Two Standards that are very detailed and cover much of the same material. One is generic and one is industry specific.

Both must be fully implemented.

The standards include how they are to interact in their contents.

Applicable Standards - NFPA 652

4.1 * General.

The owner/operator of a facility with potentially combustible dust shall be responsible for the following activities:

1. Determining the combustibility and explosibility hazards of materials in accordance with Chapter 5
2. Identifying and assessing any fire, flash fire, and explosion hazards in accordance with Chapter 7
3. Managing the identified fire, flash fire, and explosion hazards in accordance with 4.2.3
4. Communicating the hazards to affected personnel in accordance with Section 8.8

Applicable Standards - NFPA 652

7.2.2 * Qualifications.

The DHA shall be performed or led by a qualified person.

A.7.2.2

The qualified person who is leading or performing the DHA should be familiar with conducting a DHA. The qualified person should also be familiar with the hazards of combustible dusts. Typically, a team performs a DHA. For some processes this team might be a little as two persons, or for larger and more complex processes, the team might require many more than two persons.

Applicable Standards - NFPA 652

A.7.2.2 continued..

This team is made of a variety of persons whose background and expertise can include the following:

1. Familiarity with the process
2. Operations and maintenance
3. Process equipment
4. Safety systems
5. History of operation
6. The properties of the material
7. Emergency procedures

The individuals involved in the DHA could include facility operators, engineers, owners, equipment manufacturers, or consultants.

Applicable Standards - NFPA 652

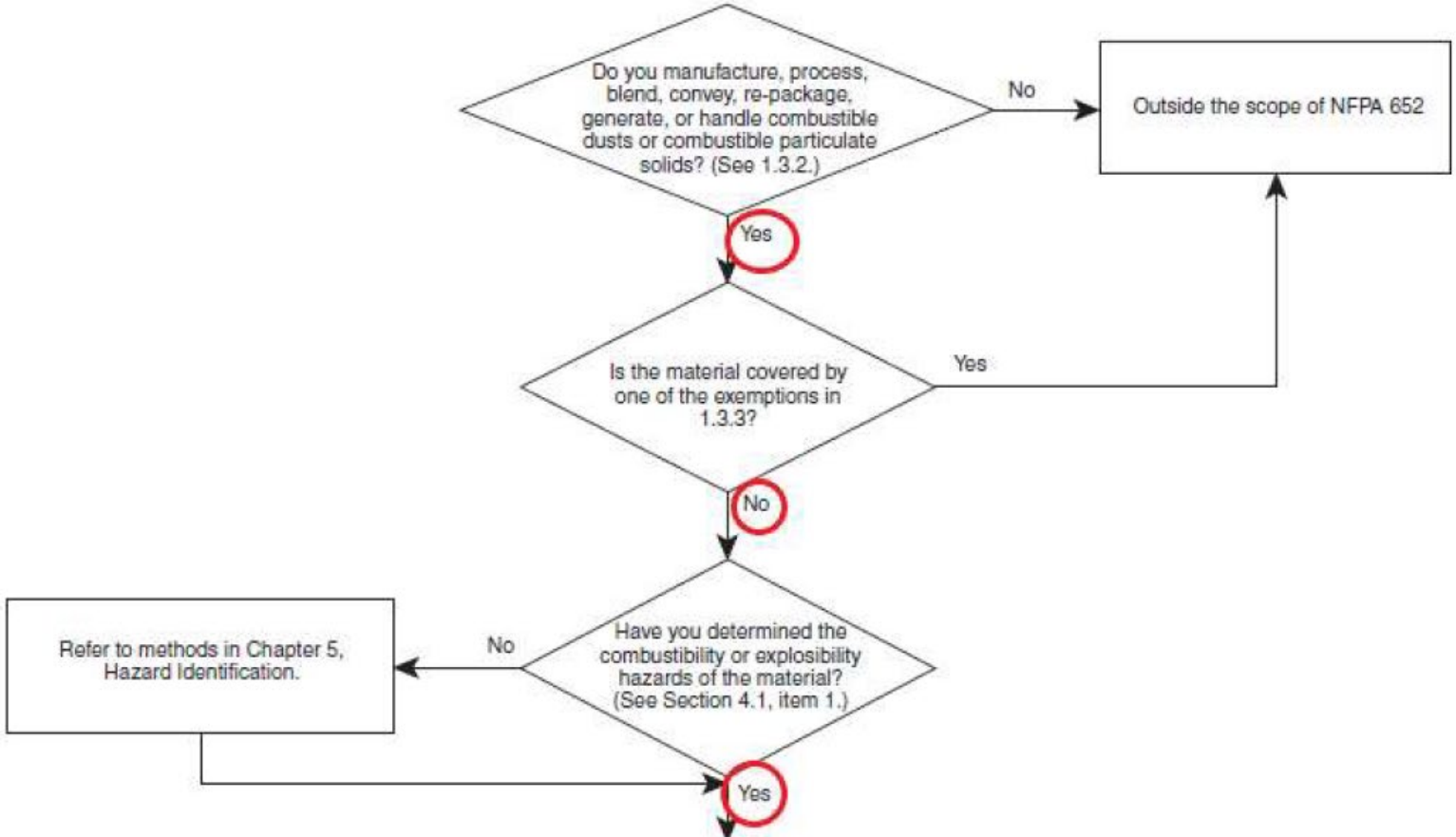
NFPA 652 Section 7 requires:

- All current processes that have the potential for a combustible dust hazard shall have a completed dust hazard analysis (DHA) by September 7, 2020.

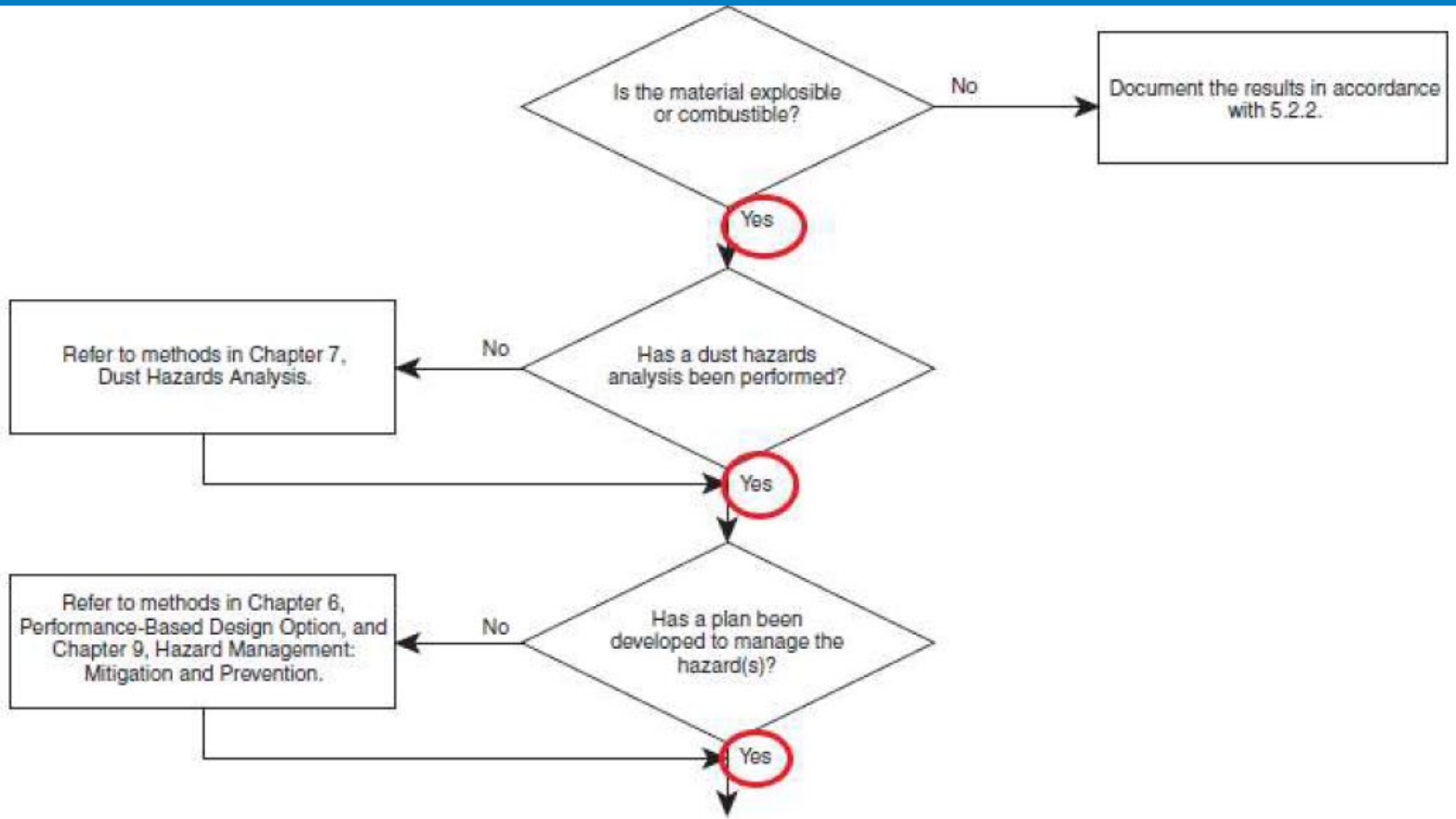
- New processes shall have a completed DHA as a part of the initial process design.

- All processes should have a DHA review every 5 years.

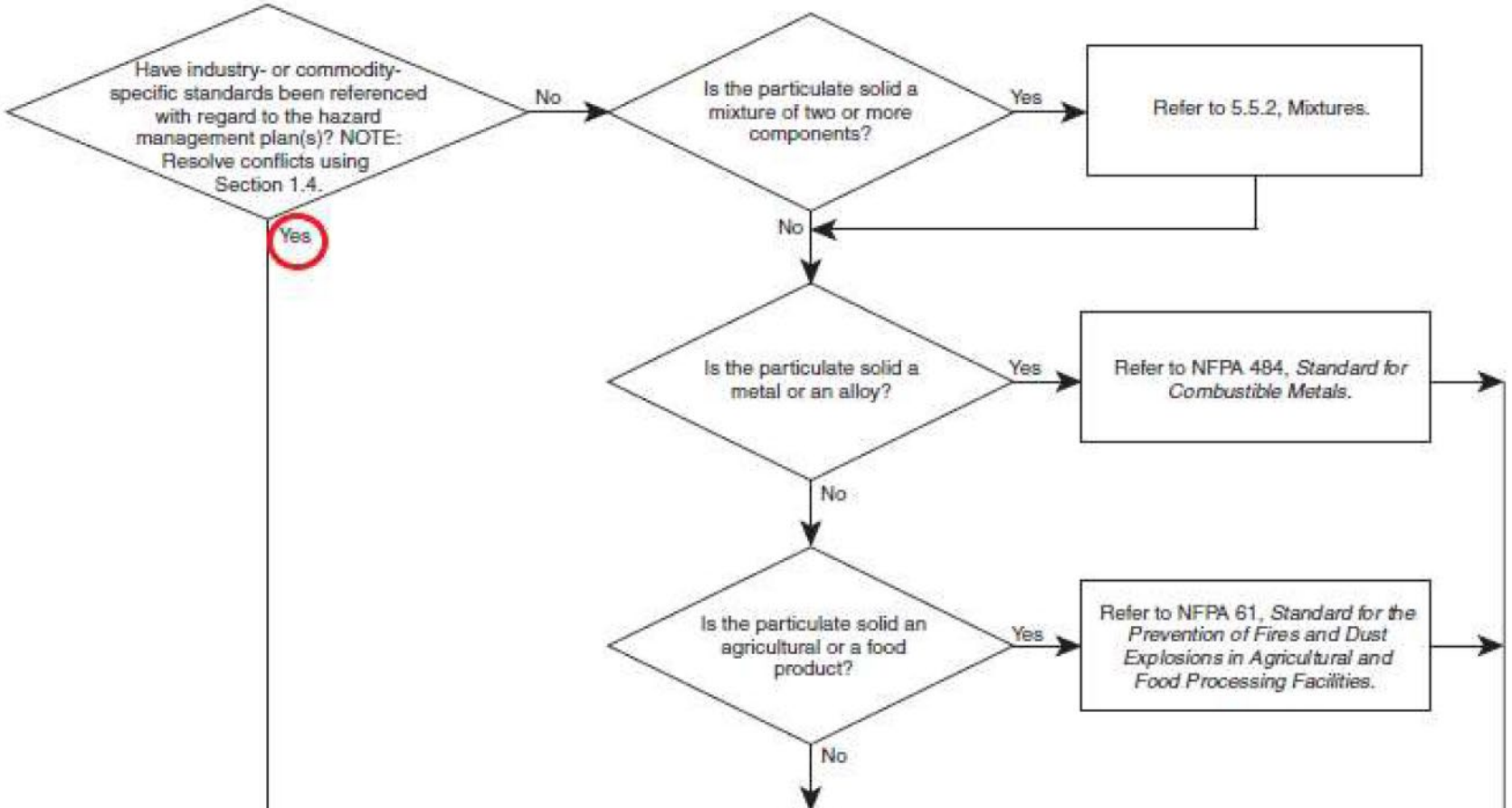
Applicable Standards - NFPA 652 Flowchart



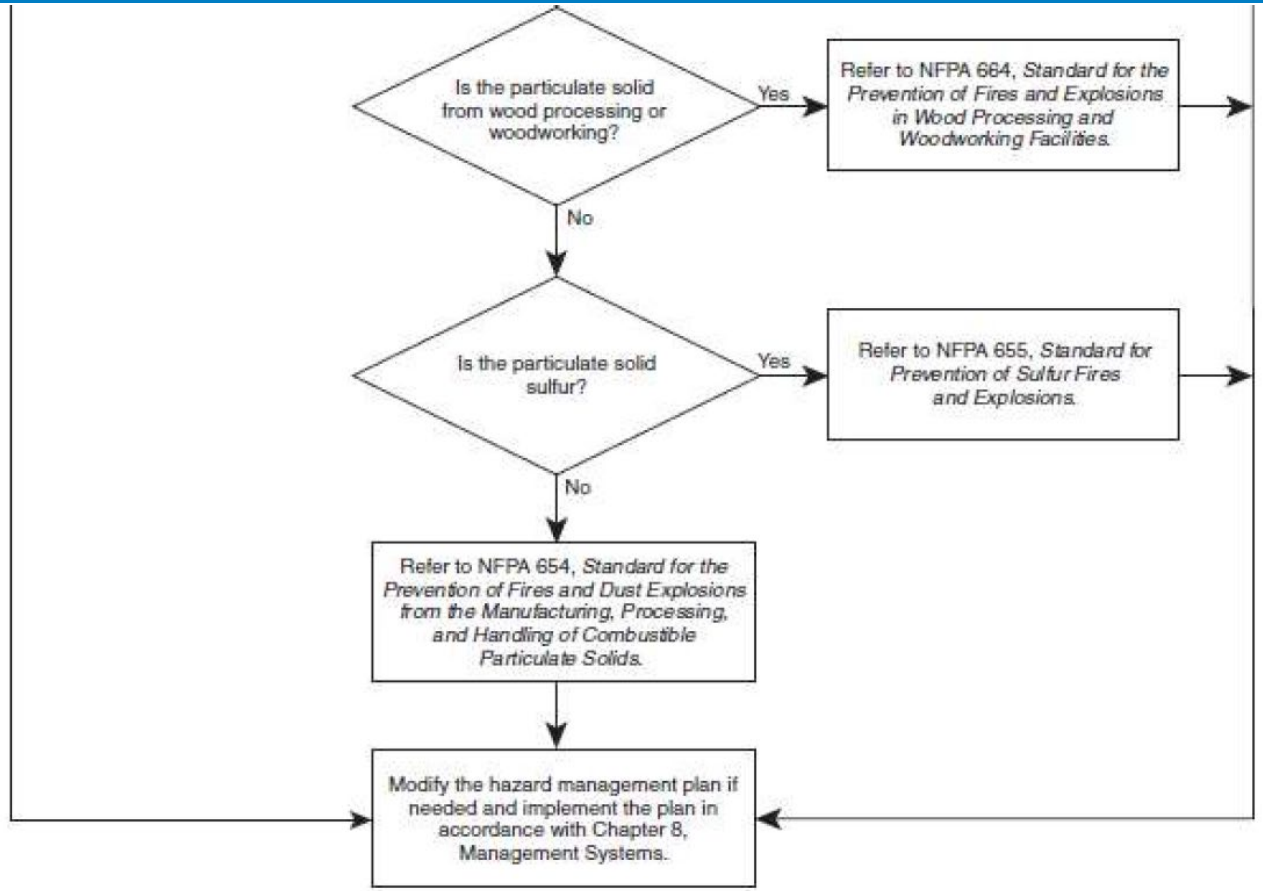
Applicable Standards - NFPA 652 Flowchart



Applicable Standards - NFPA 652 Flowchart



Applicable Standards - NFPA 652 Flowchart



NFPA 652 – Dust Hazards Analysis

There are three specific hazards that must be considered as a part of a complete dust hazard analysis:

Fire Hazard: Any situation, process, material, or condition that can cause a fire or provide a ready fuel supply to augment the spread or intensity of a fire and poses a threat to life or property.

Flash Fire: A fire that spreads by means of a flame front rapidly through a diffuse fuel, such as dust, gas, or the vapors of an ignitable liquid, without the production of damaging pressure.

Explosion: The bursting or rupture of an enclosure or container due to the development of an internal pressure from a deflagration.

NFPA 652 – Dust Hazards Analysis

Sampling Plan

Dust Testing

Hazard Analysis

Recommendations

The general process used to work through this analysis is at left

Sampling Plan

Dust Testing

Hazard Analysis

Recommendations

The sampling plan is critical because the dust tested must be the same as the dust(s) encountered in your process

NFPA 652 – Dust Hazards Analysis

Sampling Plan

Dust Testing

Hazard Analysis

Recommendations

NFPA 652 5.5.1.3

1. Identification of locations where fine particulates and dust are present
2. Identification of representative samples
3. Collection of representative samples
4. Preservation of sample integrity
5. Communication with the test laboratory regarding sample handling
6. Documentation of samples taken
7. Safe sample collection practices

NFPA 652 – Dust Hazards Analysis

Sampling Plan

Dust Testing

Hazard Analysis

Recommendations

Tests needed:

- Combustibility
- Explosibility
  - Particle size considerations

If combustible/explosible, then additional:

- KsT
- MIE
- MIT
- MEC

NFPA 652 – Dust Hazards Analysis

Sampling Plan

Dust Testing

Hazard Analysis

Recommendations

Moisture Content (wt. %)	Mean Particle Size (µm)	1.2-L Hartmann		20-L Chamber		
		Volume (ml)	Explosible (Yes/No)	Dust Concentration Tested (g/m³)	Explosion Overpressure (bar)	Explosible (Yes/No)
0.3	1280 0% < 75 µm 12% < 500 µm	5	No	500	0.0	No
		5		1000	0.0	
		5		2000	0.0	
		-		3000	0.0	

Material	Time to Ignition (sec)	Combustion Classification	Observations
sample dust	n/a	CL-1	- No ignition.

NFPA 652 – Dust Hazards Analysis

Table 1: Explosion Hazard Test Results

Material:
Room Temperature: 19°C
Relative Humidity: 30%

Operator: T. Morris
Barometric Pressure: 1000 mbar
Date of Test: April 30, 2019

Moisture Content (wt. %)	Mean Particle Size (µm)	1.2-L Hartmann		20-L Chamber		
		Volume (ml)	Explosible (Yes/No)	Dust Concentration Tested (g/m³)	Explosion Overpressure (bar)	Explosible (Yes/No)
0.5	431 32% < 75µm 77% < 500 µm	5	**Yes**	n/a	n/a	n/a

Table 3: Explosion Hazard Results

Material	P_{max}^{*} (bar)	K_{St}^{*} (bar-m/s)	MEC (g/m³)	MIE [with inductance] (mJ)
Blade Dust	7.5 ± 10%	105 ± 12%	50 < MEC < 60 $MEC_{estimate}$ = 56	10 < MIE < 30 Es = 12

NFPA 652 – Dust Hazards Analysis

Sampling Plan

Dust Testing

Hazard Analysis

Recommendations

A combustible dust that is easily ignited in small quantities with even a static spark creating explosive pressures in a small inaccessible environment with little chance of rescue.

NFPA 652 – Dust Hazards Analysis

Sampling Plan

Dust Testing

Hazard Analysis

Recommendations

- Limit dust in enclosure
- Ignition source control - tools
- Control dust dispersion
- Human element/training programs

Potential Mitigation Steps

1. Restrictions on the amount of dust accumulation both inside the vacuum system and inside the blade and adjacent hub and nacelle.

2. Vacuums shall be the primary method of housekeeping of combustible dust. Compressed air blowdown shall not be allowed.

3. No suspension mechanism during grinding activities or when dust is present. No fans or forced airflow that would aid in dust particle suspension shall be used during grinding activities.

Potential Mitigation Steps

4. Portable vacuum cleaners used to collect dust during grinding and cleanup activities shall meet the following requirements:

a. The body of the vacuum and the dirty side shall be of non-combustible construction

b. Any vacuum used shall have a dirty side volume less than 8 cubic feet

c. Hoses and vacuum tools shall be conductive and bonded to the vacuum body

Potential Mitigation Steps

d. The vacuum shall be bonded to all attachment and grounded to dissipate any potential static charge. This can be through a separate ground system or through the plug and cord of the power source. The path to ground shall be verified prior to use, after each movement or new connection, or both.

e. The fan, blower, and motor of the vacuum shall be located on the clean side of the primary filter media.

Potential Mitigation Steps

f. Intrinsically safe or Class II vacuum cleaners are not required as long as the recommendations related to dust accumulation are followed.

Informational note number one in the Class II classification section of NFPA 70 may allow for a consideration of the quantity of combustible dust in a compartment to be considered in the classification of an area depending on varying factors.

Potential Mitigation Steps

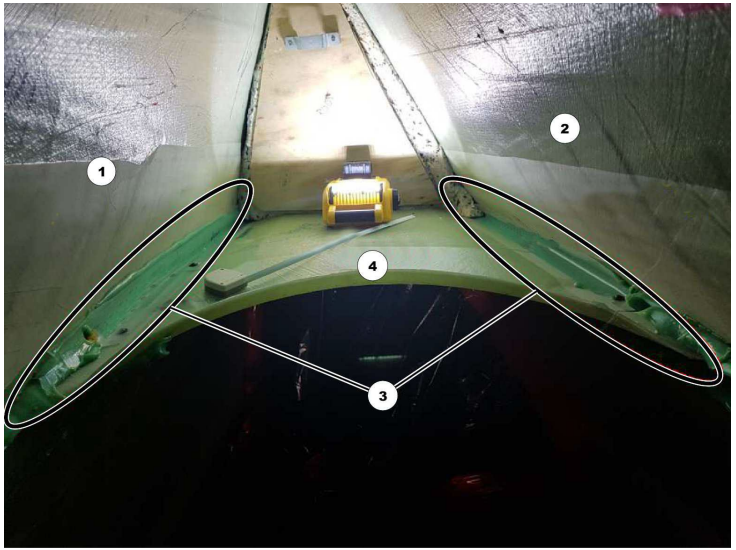
5. An inspection, testing, and maintenance program shall be implemented for all equipment.

6. An employee dust hazard training program should be developed, and completion of this program required for any affected employee.

Common Industry Approach

Technicians enter the space with the following tools:

- 4 or 7 inch angle grinder with standard abrasives
- Shop vac with combustible container
- No bonding/grounding on plastic hoses
- No limits on dust accumulation or vacuum cleanout schedule
- Fans/air horns used during the process because of confined space or heat concerns



Where do we go from here

- Get your DHA scheduled!

- JP is looking for help with research
  - Need blade sections to grind
  - Need generic process info
  - Need permission to publish in academic journals

Future Research

- Particle size is a big factor in the overall hazard.
- Particle size analysis per removal method – grinder, sander, etc.
- Particle size impact on various

Citation

NFPA 652: Standard on the Fundamentals of Combustible Dust, 2019 Edition

NFPA 654: Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids, 2020 Edition

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