RCA Name	Metal Dust Flash Fires and Hydrogen Explosion
Report Number	CSB: No. 2011-4-I-TN
Report Date	1/10/2012
RCA Owner	Chemical Safety Board/Hoeganaes Corporation

Root Cause Analysis Report

Problem Statement

Focal Point 2 Fatalities

When

Start Date	1/31/2011
Start Time	5:00am
Unique Timing	After requesting that a motor be restarted

Where

Facility	Hoeganaes Corporation: Gallatin, TN
Component	Bucket elevator # 12 and motor
Other...	Iron dust - 45 to 150 microns

Actual Impact		Cost
Safety	2 Fatalities	
Revenue	Unknown, but likely substantial	
Cost	Unknown, but likely substantial	
Other...	Publicity: Severe negative impact	
Other...	Employee Confidence: Severe negative impact	
	Actual Impact Total:	$0.00

Frequency Notes Multiple flash fires occurred in the history of the plant, but none were fatal until 1/31/2011

Report Summaries

Cause and Effect Summary

On January 31, 2011 at around 5:00AM, the [company] experienced an incident that led to two fatalities. Two employees were severely burned in an iron dust fire. The employees were wearing fire protective clothing, however this was not adequate protection due to the temperature of the fire, the contact time with the fire, and the proximity of the employees to the fire.

The two employees had been sent to repair a belt conveyor motor that had tripped. Upon examination, the employees did not find an obvious problem. One employee radioed the control room to attempt to restart the motor. This triggered an iron dust fire that immediately engulfed the two workers.

When the motor was restarted, it caused vibration in the surrounding equipment. This vibration mobilized into the air a large amount of iron dust that had settled on the equipment and surrounding structures. This dust encountered an ignition source - likely exposed wiring for the motor - and immediately ignited. It is unknown why the wiring had been left exposed. The team also discovered that the motor was not grounded properly, which could have contributed to the ignition.

There are tons of iron dust throughout the entire facility. The facility was not designed according to dust management best practices and therefore has many flat surfaces that can gather dust in areas where cleaning is difficult.

The iron dust comes primarily from muliple places in the dust handling system that are not completely sealed. Also, dust comes from open conveyor systems. The dust collection system is down frequently due to mechanical failures.

There are regulatory gaps and loopholes which prevent oversight of this type of production facility.

Solutions

ID	Label	Description		
1	**Solution**	Identify and seal leaks in dust handling system.		
	Cause	Dust handling system not completely sealed		
	Note	Inspect the plant for contributors to airborne dust through seal leaks. Rank them, and work on eliminating the largest contributors.		
	Assigned	Hoeganaes Corporation	**Criteria**	Pass
	Due		**Status**	Selected
	Term	Medium	**Cost**	$0.00
2	**Solution**	Replace with closed conveyers, or modify existing so they are enclosed		
	Cause	Open conveyers		
	Note	No notes		
	Assigned	Hoeganaes Corporation	**Criteria**	Pass
	Due		**Status**	Selected
	Term	Medium	**Cost**	$0.00
3	**Solution**	Implement housekeeping practices and standards		
	Cause	Accumulated iron dust not cleaned up		
	Note	Housekeeping should become much easier once the sources of dust are identified and eliminated.		
	Assigned	Hoeganaes Corporation	**Criteria**	Pass
	Due		**Status**	Selected
	Term	Short	**Cost**	$0.00
4	**Solution**	Conduct dyanamic analysis into dust collection system outages		
	Cause	Dust collection system frequently down		
	Note	The dust collection system has reliability problems. Complete a reliabilty assessment of the dust collection system and develop a plan to reduce the number and severity of outages.		
	Assigned	Hoeganaes Corporation	**Criteria**	Pass
	Due		**Status**	Selected
	Term	Short	**Cost**	$0.00

5	**Solution**	Develop a plan to improve the dust accumulation properties of the plant design		
	Cause	Facility design susceptible to dust accumulation		
	Note	Utilize best practices for making a facility resilient to dust accumulation.		
	Assigned	Hoeganaes Corporation	**Criteria**	Pass
	Due		**Status**	Selected
	Term	Medium	**Cost**	$0.00

7	**Solution**	Don't wait for regulatory agencies. Develop and apply standards internally.		
	Cause	Regulatory gaps (OSHA, NFPA, IFC)		
	Note	Proactively anticipate regulation and get in front of it. Conduct plant audits as if the regulations were in place.		
	Assigned	Hoeganaes Corporation	**Criteria**	Pass
	Due		**Status**	Selected
	Term	Short	**Cost**	$0.00

8	**Solution**	Completely clean the facility from top to bottom.		
	Cause	Tons of iron dust throughout facility		
	Note	The facility needs a complete cleaning. This needs to happen in conjunciton with a more effective housekeeping effort. This will likely be a one-time effort because as sources for dust are found and eliminated, less dust will accumulate.		
	Assigned	Hoeganaes Corporation	**Criteria**	Pass
	Due		**Status**	Selected
	Term	Short	**Cost**	$0.00

9	**Solution**	Clean up area before begining work		
	Cause	Iron dust on motor/elevator		
	Note	Work areas need to be clean and free from debris. Proximity to flamable iron dust was a major contributor to these two fatalities. Had the dust been removed before work began, the incident may not have occurred.		
	Assigned	Hoeganaes Corporation	**Criteria**	Pass
	Due		**Status**	Selected
	Term	Short	**Cost**	$0.00

10	**Solution**	Inspect the site for wiring hazards and fix.		
	Cause	Exposed wiring		

	Note	Open J-boxes, exposed wiring, etc are not acceptable. All instances need to be identified and fixed as soon as possible.		
	Assigned	Hoeganaes Corporation	**Criteria**	Pass
	Due		**Status**	Selected
	Term	Short	**Cost**	$0.00

11	**Solution**	Complete an audit of the facility to identify improper grounding. Ensure everything is properly grounded.		
	Cause	Motor not properly grounded		
	Note	The facility and it's components need to be properly grounded.		
	Assigned	Hoeganaes Corporation	**Criteria**	Pass
	Due		**Status**	Selected
	Term	Short	**Cost**	$0.00

12	**Solution**	Conduct PJHAs to identify risks. Wear appropriate PPE per risks identified.		
	Cause	Employees not protected		
	Note	All employees need to conduct PJHAs prior to begining a job. Make sure to identify and mitigate risks associated with any job.		
	Assigned	Hoeganaes Corporation	**Criteria**	Pass
	Due		**Status**	Selected
	Term	Short	**Cost**	$0.00

Team

ID	Label	Description	Label	Description
1	**First Name**	Brian	**Last Name**	Hughes
	Phone (1)	206-282-7703	**Phone (2)**	206-331-2569
	Role	Investigator	**Group**	
	Email	brian.hughes@sologic.com		
2	**First Name**	Hoeganaes Corporation	**Last Name**	
	Phone (1)		**Phone (2)**	
	Role		**Group**	
	Email			
3	**First Name**	Sheryl	**Last Name**	Jesse
	Phone (1)		**Phone (2)**	
	Role		**Group**	
	Email			

Evidence

ID	Label	Description
1	**Evidence**	CSB Video "Iron in the Fire", 1/05/2012
	Cause(s)	2 employees burned Severity of burns = High 2 employees positioned near ignition point Sufficient contact time Iron dust from multiple sources Iron dust ignited High temperatures Combustible iron dust cloud near motor Oxygen present Electric arc occurred (speculation) Ignition occurred near motor Employees were investigating motor shutdown Iron dust stirred up from motor/elevator surroundings Motor energized Iron dust on motor/elevator Motor/elevator vibrated Tons of iron dust throughout facility System started up Vibration occurs upon start up Dust handling system not completely sealed Open conveyers Accumulated iron dust not cleaned up Facility design susceptible to dust accumulation Regulatory gaps (OSHA, NFPA, IFC) Dust collection system frequently down
	Location	CSB Website
	Link	
	Contributor	Brian Hughes
	Type	Other
	Quality	★★★☆☆
2	**Evidence**	CSB Hoeganaes Corporation Case Study
	Cause(s)	2 employees burned Severity of burns = High 2 employees positioned near ignition point Sufficient contact time Employees not protected Iron dust ignited

High temperatures
FPC doesn't protect against large dust explosions
Employees wear Fire Protective Clothing (FPC)
Combustible iron dust cloud near motor
Oxygen present
Electric arc occurred (speculation)
Ignition occurred near motor
Employees were investigating motor shutdown
Iron dust stirred up from motor/elevator surroundings
Exposed wiring
Motor not properly grounded
Motor energized
Iron dust on motor/elevator
Motor/elevator vibrated
Tons of iron dust throughout facility
System started up
Vibration occurs upon start up
Dust handling system not completely sealed
Open conveyers
Accumulated iron dust not cleaned up
Facility design susceptible to dust accumulation
Regulatory gaps (OSHA, NFPA, IFC)
Dust collection system frequently down

Location http://www.csb.gov/assets/document/CSB_Case_Study_Hoeganaes_Dec9_Final.pdf
Link
Contributor Brian Hughes
Type Document
Quality ★★★☆☆

3 **Evidence** Statement - Sheryl
Cause(s) System started up
Oxygen present

Location
Link
Contributor Sheryl Jesse
Type Document
Quality ★★★★★

Chart Type Legend

- Transitory
- Non-transitory
- Omission - Transitory
- Omission - Non-transitory
- Focal Point
- Solution Implemented

2 Fatalities

Evidence
CSB Video "Iron in the Fire", 1/05/2012
CSB Hoeganaes Corporation Case Study

2 employees burned

Evidence
CSB Video "Iron in the Fire", 1/05/2012
CSB Hoeganaes Corporation Case Study

Iron dust ignited

Evidence
CSB Video "Iron in the Fire", 1/05/2012
CSB Hoeganaes Corporation Case Study

Severity of burns = High

Evidence
CSB Video "Iron in the Fire", 1/05/2012
CSB Hoeganaes Corporation Case Study

High temperatures

Evidence
CSB Video "Iron in the Fire", 1/05/2012
CSB Hoeganaes Corporation Case Study

END

Terminated because:
Other causal paths more productive

Sufficient contact time

Evidence
CSB Video "Iron in the Fire", 1/05/2012
CSB Hoeganaes Corporation Case Study

END

Terminated because:
Other causal paths more productive

Employees not protected

Evidence
CSB Hoeganaes Corporation Case Study

Solutions

Conduct PJHAs to identify risks. Wear appropriate PPE per risks identified.

Criteria Pass Status Selected

All employees need to conduct PJHAs prior to begining a job. Make sure to identify and mitigate risks associated with any job.

FPC doesn't protect against large dust explosions

Evidence
CSB Hoeganaes Corporation Case Study

END

Terminated because:
Other causal paths more productive

Employees wear Fire Protective Clothing (FPC)

Evidence
CSB Hoeganaes Corporation Case Study

END

Terminated because:
Other causal paths more productive

2 employees positioned near ignition point

Evidence
CSB Video "Iron in the Fire", 1/05/2012
CSB Hoeganaes Corporation Case Study

Ignition occurred near motor

Evidence
CSB Video "Iron in the Fire", 1/05/2012
CSB Hoeganaes Corporation Case Study

END

Terminated because:
Other causal paths more productive

Electric arc occurred (speculation)

Evidence
CSB Video "Iron in the Fire", 1/05/2012
CSB Hoeganaes Corporation Case Study

Motor not properly grounded

Evidence
CSB Hoeganaes Corporation Case Study

Solutions

Complete an audit of the facility to identify improper grounding. Ensure everything is properly grounded.

Criteria Pass Status Selected

The facility and it's components need to be properly grounded.

Motor energized

Evidence
CSB Video "Iron in the Fire", 1/05/2012
CSB Hoeganaes Corporation Case Study

END

Terminated because:
Other causal paths more productive

Oxygen present

Evidence
CSB Video "Iron in the Fire", 1/05/2012
CSB Hoeganaes Corporation Case Study
Statement - Sheryl

END

Terminated because:
Other causal paths more productive

Exposed wiring

Evidence
CSB Hoeganaes Corporation Case Study

Solutions

Inspect the site for wiring hazards and fix.

Criteria Pass Status Selected

Open J-boxes, exposed wiring, etc are not acceptable. All instances need to be identified and fixed as soon as possible.

Here is a new solution

Criteria Pass Status Selected

Here is a note

Combustible iron dust cloud near motor

Evidence
CSB Video "Iron in the Fire", 1/05/2012
CSB Hoeganaes Corporation Case Study

Iron dust stirred up from motor/elevator surroundings

Evidence
CSB Video "Iron in the Fire", 1/05/2012
CSB Hoeganaes Corporation Case Study

Iron dust on motor/elevator

Evidence
CSB Video "Iron in the Fire", 1/05/2012
CSB Hoeganaes Corporation Case Study

Solutions

Clean up area before begining work

Criteria Pass Status Selected

Work areas need to be clean and free from debris. Proximity to flamable iron dust was a major contributor to these two fatalities. Had the dust been removed before work began, the incident may not have occurred.

Motor/elevator vibrated

Evidence
CSB Video "Iron in the Fire", 1/05/2012
CSB Hoeganaes Corporation Case Study

System started up

Evidence
CSB Video "Iron in the Fire", 1/05/2012
CSB Hoeganaes Corporation Case Study
Statement - Sheryl

END

Terminated because:
Other causal paths more productive

Vibration occurs upon start up

Evidence
CSB Video "Iron in the Fire", 1/05/2012
CSB Hoeganaes Corporation Case Study

Tons of iron dust throughout facility

Evidence
CSB Video "Iron in the Fire", 1/05/2012
CSB Hoeganaes Corporation Case Study

Solutions

Completely clean the facility from top to bottom.

Criteria Pass Status Selected

The facility needs a complete cleaning. This needs to happen in conjunciton with a more effective housekeeping effort. This will likely be a one-time effort because as sources for dust are found and eliminated, less dust will accumulate.

Iron dust from multiple sources

Evidence
CSB Video "Iron in the Fire", 1/05/2012

Accumulated iron dust not cleaned up

Evidence
CSB Video "Iron in the Fire", 1/05/2012
CSB Hoeganaes Corporation Case Study

Solutions

Implement housekeeping practices and standards

Criteria Pass Status Selected

Housekeeping should become much easier once the sources of dust are identified and eliminated.

Dust handling system not completely sealed

Evidence
CSB Video "Iron in the Fire", 1/05/2012
CSB Hoeganaes Corporation Case Study

Solutions

Identify and seal leaks in dust handling system.

Criteria Pass Status Selected

Inspect the plant for contributors to airborne dust through seal leaks. Rank them, and work on eliminating the largest contributors.

Redesign system to ensure there are no leaks

Criteria Pass Status Identified

Open conveyers

Evidence
CSB Video "Iron in the Fire", 1/05/2012
CSB Hoeganaes Corporation Case Study

Solutions

Replace with closed conveyers, or modify existing so they are enclosed

Criteria Pass Status Selected

No notes

Why?

Dust collection system frequently down

Evidence
CSB Video "Iron in the Fire", 1/05/2012
CSB Hoeganaes Corporation Case Study

Solutions

Conduct dyanamic analysis into dust collection system outages

Criteria Pass Status Selected

The dust collection system has reliability problems. Complete a reliability assessment of the dust collection system and develop a plan to reduce the number and severity of outages.

Facility design susceptible to dust accumulation

Evidence
CSB Video "Iron in the Fire", 1/05/2012
CSB Hoeganaes Corporation Case Study

Solutions

Develop a plan to improve the dust accumulation properties of the plant design

Criteria Pass Status Selected

Utilize best practices for making a facility resilient to dust accumulation.

Consider building a new facility

Criteria Fail Status Identified

This is not feasible at this time, but employ for future plant designs.

Regulatory gaps (OSHA, NFPA, IFC)

Evidence
CSB Video "Iron in the Fire", 1/05/2012
CSB Hoeganaes Corporation Case Study

Solutions

Don't wait for regulatory agencies. Develop and apply standards internally.

Criteria Pass Status Selected

Proactively anticipate regulation and get in front of it. Conduct plant audits as if the regulations were in place.