CARBON BLACK

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1.0 SCOPE

This document provides loss prevention recommendations for carbon black manufacturing facilities. The predominate manufacturing method is the partial combustion of heavy oils, which is the focus of this data sheet.

1.1 Hazards

The carbon black production process involves large, fuel-fired equipment, flammable gas and combustible dust. In addition, the process generates significant waste energy, which can be reclaimed through in-process, sensible heat recovery and through the separate combustion of tail gas generated from the carbon black manufacturing process. The vast majority of combusted tail gas is used to co-generate power. The leading loss drivers in the occupancy are breakdown of rotating equipment and power generation equipment, and fires in the power generation unit. Other hazards include fire and explosion in the production units, major equipment failure and natural hazards.

1.2 Changes

October 2026. Interim revision. Editorial changes were made throughout the document. Significant changes include the following:

A. Reviewed Section 2.2.3 to remove specific safety controls and interlocks for carbon black reactors, recognizing that field installations may differ because multiple reactor technologies are used across the industry.

B. Added clarification in Section 2.2.3.4 for the high-temperature interlock of the main baghouse.

C. Reviewed Section 2.3 to clarify information about fire detection and interlocks above the face of the reactors, pumps and preheaters.

D. Added guidance in Section 2.3.5.2 for the protection of bulk carbon black stored on non-FM Approved plastic pallets.

2.0 LOSS PREVENTION RECOMMENDATIONS

2.1 Construction and Location

2.1.1 Locate process reactors using natural gas or liquid fuel as a feedstock away from the control room, control equipment, feedstock heaters and warehousing. For additional guidance see Data Sheet 7-14, *Fire Protection for Chemical Plants*.

2.2 Process Hazards/Safety

2.2.1 Process Safety

2.2.1.1 Establish a formal process safety program in accordance with Data Sheet 7-43, *Process Safety*. Place emphasis on the following:

A. Process hazard analysis for routine and non-routine operations, including process shutdown, startup and emergency conditions. Evaluate credible high-temperature and high-pressure excursion, equipment failures, and potential fire and explosion scenarios. Ensure effective controls are implemented and maintained to prevent or mitigate associated risks.

B. Conditions to prevent coking of the preheaters and reactors, including preventive measures that inhibit coking in the feedstock system

C. Detailed operator training programs with training on all safety shutdowns, including non-routine operations

D. Management of changes process that focuses on temporary bypasses, updates to P&IDs and completion tracking

E. Incident investigations of all major failures, including but not limited to, safety interlocks, devices and combustion controls

F. Asset integrity programs focused on rotating equipment, power generation, and accelerated corrosion

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2.2.2 Chemical/Material Hazards

2.2.2.1 Protect equipment handling combustible dust in accordance with Data Sheet 7-76, *Combustible Dusts.*

2.2.2.2 Ensure that bags and filter media materials are suitable for handling very fine carbon black particles and the elevated temperatures associated with tail gases.

2.2.3 Safety Controls, Alarms and Interlocks

2.2.3.1 Provide reactors with combustion safeguards and interlocks for startup and operation according to Data Sheet 6-10, *Process Furnaces*.

2.2.3.2 Provide combustion controls for startup and operation of the dryer in accordance with Data Sheet 6-17, *Rotary Kilns and Dryers*.

2.2.3.3 For startup and operation of downstream product collection, heat recovery, and tail gas, ensure a diversion stack is provided to divert stream gases for startup operations and process upset conditions.

2.2.3.4 Provide a high-temperature interlock on the main baghouse to prevent damage from process temperature excursions. Design it to automatically initiate mitigation measures to maintain the baghouse operating temperature within the design limits of the filter media and associated equipment. Mitigation measures may include, but are not limited to:

A. Diverting the tail gas stream to a safe bypass or diversion stack

B. Automatically initiating a secondary quench water system

C. Initiating a controlled process shutdown

2.3 Protection

2.3.1 Provide fire detection directly above the face of reactors, pumps and preheaters. Interlock the fire detection system with the process control to alarm at a constantly attended area and to automatically bring the process to a safe state as determined by a process hazard analysis (PHA).

2.3.2 Automatic sprinkler protection is not required for pumps, preheaters and reactors located outdoors if all the following conditions are met:

A. Fire detection and interlocks are provided in accordance with Section 2.3.1.

B. Manual firefighting is provided for the burner front of the pumps, preheaters, and reactors, according to Data Sheet 7-14, *Fire Protection for Chemical Plants*.

C. There are no factors that could increase a fire exposure, such as combustible construction elements, storage of combustible materials, lack of emergency organization, etc.

2.3.3 Provide automatic sprinkler protection in buildings containing oil-fired reactors.

2.3.4 Provide manual firefighting protection for the facility, according to Data Sheet 7-14, *Fire Protection for Chemical Plants*. Ensure the burner front of the reactors, the bag house, palletized storage of carbon black and other critical areas can be adequately protected.

2.3.5 Segregate carbon black storage from storage of ordinary combustibles and packing materials. Automatic sprinkler protection is not required for carbon black storage areas when wooden or FM Approved plastic pallets are used. Sprinkler protection of carbon black storage areas is warranted under any of the following conditions:

A. Presence of combustible construction materials

B. Presence of packaging materials or other combustibles in the area

C. Use of Non-FM Approved plastic pallets

2.3.5.1 Provide automatic sprinkler protection for warehouses used for storage of packaging materials, or if combustible building construction exists, according to Data Sheet 8-9, *Storage of Class 1, 2, 3 and Plastic Commodities*.

2.3.5.2 Protect areas storing carbon black on non-FM Approved plastic pallets according to Data Sheet 8-9, *Storage of Class 1, 2, 3, 4 and Plastic Commodities*, using a Class 2 commodity classification.

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2.3.6 Provide automatic sprinkler protection for lubricating oil systems over steam turbines and generators in accordance with Data Sheet 7-101, *Fire Protection for Steam Turbines and Electric Generators*.

2.4 Equipment and Processes

2.4.1 For operations in which tail gases are used for steam production and power generation, follow the protection guidelines in Data Sheet 7-101, *Fire Protection for Steam Turbines and Electric Generators*.

2.4.2 For guidance on rotary equipment, see Data Sheet 6-17, *Rotary Kilns and Dryers*.

2.4.3 For guidance on fans and blowers, see Data Sheet 13-24, *Fans and Blowers.*

2.4.4 Use double-braided, noncombustible hose in all feed stock supply lines. Ensure these are capable of withstanding four times the normal maximum operating pressure. For additional information, see Data Sheet 7-32, *Ignitable Liquid Operations*.

2.5 Operation and Maintenance

Significant equipment-related hazards at this occupancy include the potential for a mechanical or electrical distribution failure. The likelihood of such an event is greatly reduced by thorough and varied inspection, maintenance, and operating programs, contingency plans, and effective safeguards to prevent these types of events.

2.5.1 Establish an asset integrity monitoring program in accordance with Data Sheet 9-0, *Asset Integrity*.

3.0 SUPPORT FOR RECOMMENDATIONS

3.1 Loss History

Figure 3.1 provides a summary of all losses between 2004 and 2017 for this occupancy.

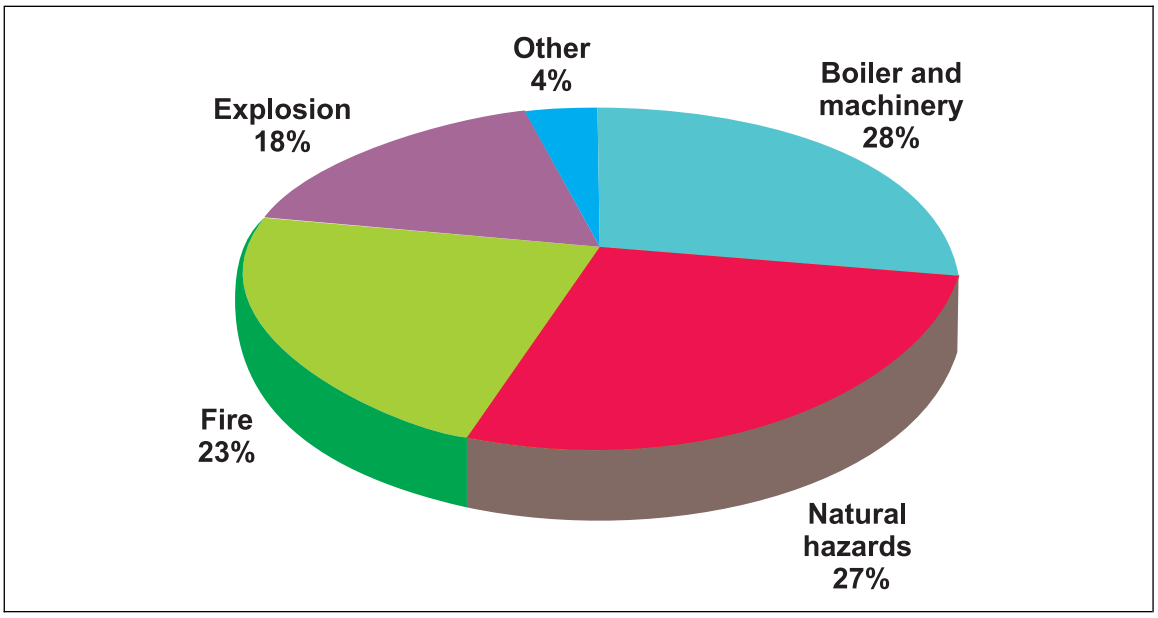


Fig. 3.1. Summary of Losses (2004-2017)

Boiler and machinery losses were driven by damage to heat exchangers in the heat recovery section of the plant, damage to turbines and generators, and electrical breakdown. The damaged heat exchangers were the result of coking tubes, loss of flow of process oil, leakage, and tube cracking. Damage to turbines and generators included loss of lubrication and other common perils described in Data Sheet 7-101, *Fire Protection for Steam Turbines and Electric Generators*. Electrical damage was predominately related to

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service interruption and transformers. All the losses are typical B&M hazards for the type of equipment involved. A high degree of focus should be placed on heat exchangers, cogeneration equipment, and electrical reliability.

The fire losses were driven by fires on or around steam turbine generators. These events would have been mitigated with the fire protection recommended in Data Sheet 7-101, with the exception of one event that occurred during the installation of sprinklers. There was only one loss involving reactors, in which refractory collapsed inside the reactors, damaged a nozzle and fire extended from the reactors, damaging cabling and various equipment.

Explosion losses were predominately combustion explosions involving carbon monoxide in the filter and heat recovery sections of the plant. These sections of the plant are designed to operate with depleted oxygen (fuel rich) and poor startup procedures or other process upsets allowed oxygen into these areas of the plant, creating a flammable atmosphere. There were no reported losses in this period involving combustible dust.

Natural hazard losses were driven by hurricane events in the US gulf coast. This includes several flooding events at locations in known flood zones. There is nothing atypical in the natural hazard losses. Damage percentages are typically modest provided flood levels do not reach the height of reactors' refractory.

3.2 Process Overview

Carbon black is produced through the controlled reaction of hydrocarbon feedstock oil with a limited supply of combustion air within a reactor. In this process, preheated air and feedstock oil are introduced into the reactor where partial combustion occurs, generating a high-temperature gas stream consisting of carbon black particles and tail gas. This stream is rapidly quenched with water to reduce the temperature and terminate the reaction.

The properties of the carbon black produced are controlled by adjusting process conditions, particularly the oil-to-air ratio and reactor temperature. These parameters influence particle size, structure and degree of aggregation.

Carbon black products are generally classified into two main categories: rubber grades and specialty grades. Rubber-grade carbon black, which accounts for approximately 90% of total production, is primarily used to reinforce rubber products and is categorized under ASTM 1765-01 by N-series numbers (typically N200 to N800). Specialty carbon black grades are used for pigmentation, UV protection and electrical conductivity.

Upon exiting the reactor, the carbon black is conveyed through a cooling and separation system. It is typically collected using bag filters in a continuous process. The remaining gas stream, known as tail gas, contains combustible components such as carbon monoxide and hydrogen. Many facilities recover the energy value of this gas for process heating, steam generation or power production; while excess gas may be directed to a thermal oxidizer for emissions control. Figure 3.2 represents a simple carbon black process.

Most processes are single-line process flows with various bottlenecks, including utilities, reactors, blowers, dryers and air pollution control systems.

The reactors range in size from 4 to 8 ft (1.2 to 2.5 m) in diameter and up to 120 ft (37 m) long. Reactors are generally steel shell lined with refractory brick and can be fed axially, tangentially or radially. The hot reactor stream is used to preheat the combustion air in the heat exchanger.

The airflow is usually 5,000-6,000 cfm (8,500 - 10,200 m^3/hr.) with many plants sized at 12,000 scfm (20,300 m^3/hr.) or more. The pressure is usually up to 15 psig (1 barg). Therefore, large motors (1,000 hp and up) can be seen on air blowers which may require extensive lead time for replacement.

Large rotary dryers, typically 8 ft (2.4 m) in diameter and up to 75 ft (23 m) long are used to dry the pelletized carbon black. These dryers can be direct or indirect fired (waste heat from the process).

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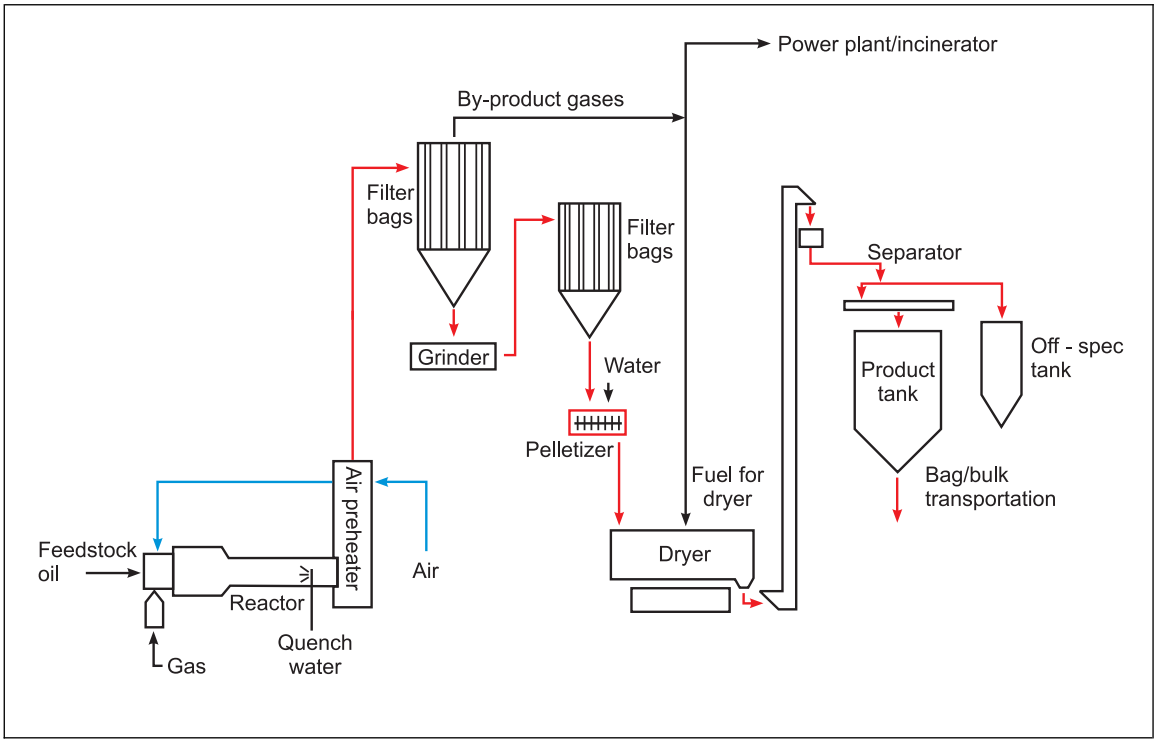


Fig. 3.2. Carbon black process diagram

3.3 Equipment

3.3.1 Hoses

Braided feedstock hoses should be replaced in accordance with the manufacturer's recommendations, considering service conditions, frequency of use and the results of a local risk assessment. A common issue with aging hoses is reduced flexibility, which can lead to leakage at threaded connections or fittings, or even hose failure—particularly where 90-degree bends or tight routing exist.Hoses exhibiting signs of deterioration—such as bulging, stiffness, cracking or corrosion—require immediate inspection and prompt replacement.

In this service, hoses are subjected to a range of demanding conditions, including tensile and compressive stresses, internal pressure, temperature extremes, vibration, corrosive environments, physical impact and reactive forces. To minimize the effects of these conditions and ensure safe operation, the manufacturer's recommendations for installation, operation and maintenance should be followed.

3.3.2 Distributed Control Systems (DCS)

Typical DCS configurations are utilized for process control. These systems typically combine to provide control features needed for plant start-up, shutdown, combustion safeguards, production optimization, emergency stops, etc. Loss of DCS in an emergency shutdown can cause fouling from coking in the feedstock system.

4.0 REFERENCES

4.1 FM

Data Sheet 6-10, *Process Furnaces*
Data Sheet 6-17, *Rotary Kilns and Dryers*
Data Sheet 7-14, *Fire Protection for Chemical Plants*
Data Sheet 7-43, *Process Safety*
Data Sheet 7-76, *Prevention and Mitigation of Combustible Dust Explosion and Fire*
Data Sheet 7-101, *Fire Protection for Steam Turbines and Electric Generators*

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Data Sheet 8-9, *Storage of Class 1, 2, 3, 4 and Plastic Commodities*
Data Sheet 9-0, *Asset Integrity*
Data Sheet 13-24, *Fans and Blowers*

APPENDIX A GLOSSARY OF TERMS

See also Data Sheet 7-111.

Combustible dust: Any organic material (agricultural, plastic, chemical, coal, etc.), unoxidized metal particles, or other oxidizable materials (e.g., zinc stearate) should be considered combustible. Tests involving the application of a spark, match flame, Bunsen or Meker burner flame to small layers or piles of material may help in identifying such materials but can result in false negatives.

APPENDIX B DOCUMENT REVISION HISTORY

The purpose of this appendix is to capture the changes that were made to this document each time it was published. Please note that section numbers refer specifically to those in the version published on the date shown (i.e., the section numbers are not always the same from version to version).

October 2026. Interim revision. Editorial changes were made throughout the document. Significant changes include the following:

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October 2024. Interim revision. Minor editorial changes were made.

January 2023. Interim revision. Minor editorial changes were made.

October 2020. Interim revision. Minor editorial changes were made.

July 2019. This is the first publication of this document.

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