CARBON BLACK PLANTS

INTRODUCTION

Carbon black is a generic term for an important ingredient in many products. It is a low density powder of extreme fineness and porosity with a high surface area, composed essentially of elemental carbon. About 80% of all carbon black produced is used to reinforce rubber. The rest is used as a black pigment or for its electrically conductive properties.

PROCESSES AND HAZARDS

Several processes have been used to produce carbon black, including the lampblack process, the impingement or channel process, the gas furnace process, the thermal process, the oil-furnace process and the acetylene process. These processes produce different grades of carbon black. They are referred to by the process name, e.g., lampblack, thermal black, etc. Carbon black should not be confused with coke, which is produced by heating coal in the absence of oxygen. Even if coke is further processed by calcining, it still contains too many impurities (mostly minerals) to be used in place of carbon black. The residual impurities in carbon black are leftover hydrocarbons, not minerals.

The lampblack, channel and gas furnace processes are no longer used. The oil-furnace process produces carbon black which is 97% elemental carbon. It is also the most commonly used process, producing over 95% of all carbon black. The remainder of the market is filled by thermal or acetylene black, which consist of over 99% carbon.

Processes

Oil-Furnace

Natural gas is injected into a reactor vessel where it burns in preheated air. The feedstock oil is sprayed into the resulting hot, oxygen-poor products of natural gas combustion. The oil decomposes during incomplete combustion into carbon black and hydrogen. Quench water is sprayed into the reactor to stop the combustion reaction before it consumes the carbon black. The product stream then passes through heat exchangers. The heat is used to preheat the combustion air and the oil feedstock. The product stream is then quenched with water once again and passes through a bag filter. The off-gases from the bag house are combustible and are burned in plant equipment or sent to a flare. The carbon black is combined with water, pelletized and dried in a rotary dryer. The dryer is usually fired by the off-gases. The finished carbon black is stored and shipped in bulk, in large cardboard boxes or in paper bags on wood pallets.

Thermal

This process uses natural gas, coke oven gas or liquid hydrocarbons. The process furnaces are arranged in pairs and alternate every 5 min between preheating and carbon black production. The

feedstock is injected into a hot refractory-lined furnace. In the absence of air, the heat from the refractory decomposes the feedstock into carbon and hydrogen. The product stream is quenched with water sprays and filtered in a bag house. The carbon black is pelletized and then shipped. The hydrogen off-gas is burned in air to preheat the second furnace.

Acetylene

In this process, acetylene gas is fed into a hot refractory-lined water cooled reactor where it decomposes exothermically in the absence of air into carbon and hydrogen. The product stream is cooled and filtered. The carbon black is packaged and shipped. The hydrogen off-gas is flared or burned for fuel in plant equipment.

Hazards

Raw Materials

Oil - Feedstock oil is usually a Class III combustible liquid. It possesses the same hazards during storage and handling as any other heavy oil. These hazards are basically those of spill fires and torch fires.

Natural Gas - Natural gas poses hazards of torch fires or gas combustion explosions.

Acetylene - Acetylene has the same torch fire and gas combustion explosion potential as natural gas, but it can also decompose explosively.

Reactors

Both thermal and oil-furnace reactors are essentially fire boxes where fuel and air are burned at atmospheric pressure. As such, they have the same hazards as any other fired heater, namely firebox explosions and overfiring. The acetylene reactor handles a decomposition reaction so it is susceptible to explosions and overheating due to loss of cooling.

Off-gas

The off-gas stream contains hydrogen and carbon monoxide, and is therefore flammable. Pressure leaks can lead to torch fires or explosions. If a process upset allows enough oxygen into the process stream, an explosion can occur in the ducts or piping handling the stream.

Bag Houses

These bag type filters handle a combination of flammable gas and combustible dust. They are vulnerable to explosions and fires. While carbon black is combustible, it is hard to ignite so there is seldom any residual fire once the gas is consumed.

Dryers

These natural gas or off-gas fired units can have firebox explosions or can be overfired.

Finished Product

Carbon black in its finished form is combustible but is difficult to ignite and burns very slowly. Without being mixed with off-gas, it requires an intense igniter to cause a dust explosion. However, after contaminating carbon black with hydrocarbons, spontaneous ignition can occur within 24 hours. Since carbon black is made from hydrocarbons, a process flaw could produce carbon black with hydrocarbon contamination, leading to a fire.

Carbon black mixed with water forms an extremely effective lubricant and, if spilled on a floor, prevents the safe movement of personnel and equipment.

Warehousing

Carbon black stored in paper bags on wood pallets is vulnerable to fire. Typically these fires are caused by spontaneous ignition of contaminated product in its first 24 hours. These fires grow and spread very slowly. Because of the lubricating properties of carbon black and water, some facilities are very reluctant to provide sprinklers in carbon black warehouses, depending upon the slow fire

growth to provide time for detection and manual overhaul. However, any empty paper bags or wood pallets mixed with the carbon black storage can lead to a fast growing, intense fire.

LOSS PREVENTION AND CONTROL

Management Programs

Management program administrators should report to top management through the minimum number of steps. They should also institute adequate loss prevention inspection and audit programs to communicate program effectiveness to top management. This management feedback is a key feature of *OVERVIEW* (PRC.1.0.1), AXA XL Risk Consulting's total management program for loss prevention and control. In developing a program, pay particular attention to the following important areas:

Hazardous Materials

Determine the pertinent physical and chemical properties of any raw material to be used. Choose test conditions that represent operating conditions.

Establish routine procedures for testing all incoming raw materials to confirm properties required for safe operating conditions. If the volatility, flashpoint or some other physical property of the feedstock is off specification, a process upset or explosion could result.

Process Hazards Evaluation

When designing processes, minimize the reactor material hold-up. Smaller vessels with less holdup provide less material to explode in the event of equipment failure or operator error.

Determine the safe operating and potential upset conditions of all new or existing reactors used by the plant. Include scaling factors (bench, pilot, semi-works, full scale, etc.) when establishing the safety parameters.

Design all processes using failsafe instrumentation and enforce adherence to written operating procedures, and provide ultimate safety by adequate pressure relieving devices. Interlock processes to shut down automatically and safely in event of operator error or equipment failure. Provide intermediate alarms to allow operators time to take corrective action.

Provide redundant instrumentation loops for all critical controls. In redundant loops, duplicate **both** signal transmitters and signal receivers. Install a comparator to notify operators when redundant signals differ significantly.

To limit the amount of materials released by equipment failure, include the following in shut-down measures: block valves; venting to flare stacks; and purging or flooding of equipment with a nonhazardous fluid. Actuate these shutdown measures with combustible vapor detectors.

When designing safety features, assume a minimum of two consecutive errors, one of which may be misinformation because of a faulty instrument or a misunderstanding of instructions.

Design and specify equipment considering all possible operating conditions, both normal and abnormal. Give particular attention to suitability of the equipment to handle the process materials and to withstand external environmental influences.

Operator Training

Educate all operators in the hazards involved and in functions of the safety control equipment. Forbid operators to run the process when any of this equipment is out of order. Train operators in manual emergency shut-down procedures. Forbid deviations from the written procedures.

Schedule re-education and training at least annually. Include testing to assure proper performance of all assigned duties with particular emphasis on emergency shutdowns.

Pre-Emergency Planning

The pre-emergency plan from *OVERVIEW*, may be used to develop a customized plan. This customized plan should include the following features:

- A fire and disaster alarm system.
- An emergency communications system, including radio where needed.
- An adequately trained, staffed and equipped organization of employees for firefighting and other emergency duties.
- A planned program of cooperation with neighboring plants and with public firefighting and disaster control organizations.
- A program to analyze the interruption of business that may result from potential incidents and to develop plans for minimizing loss of production during rebuilding.

Preventive Maintenance and Inspection

Inspect and maintain process equipment, piping, instrumentation, electrical equipment and pressure relief devices according to a schedule established with proper consideration to design and service conditions. Include all appropriate types of modern nondestructive testing, IR scanning and vibration analysis in the inspection techniques. Establish a detailed record-keeping system which includes equipment retirement forecasts.

Housekeeping

Establish appropriate levels of cleanliness. Remember, carbon black poses a dust hazard when dry and a slipping problem when wet. Appoint a responsible supervisor and provide him or her with adequate personnel, equipment and supplies to maintain an adequate level of housekeeping.

Management of Change

Apply all management programs to any changes which are made to the facility's physical arrangements or procedures. Pay particular attention to the following areas:

- Repeat the process hazards evaluations program for all new processes or for any modification to an existing process. Determine the need for new or different safety equipment or measures.
- Whenever equipment is changed from one service to another, or when process changes are made, examine the inspection and maintenance program and modify as necessary. Monitor daily operating changes.
- Verify new construction materials and all maintenance parts and supplies as conforming to original (or modified) design specifications.
- Apply the program for handling new construction, including the control of outside contractors.
- Update operations procedure manuals after each process unit modification which results in a change in operating procedure.
- Review and follow through expeditiously on all inspection recommendations from insurance, code enforcement and regulatory agencies.

Other Management Programs

Incorporate these features into the comprehensive management program for loss prevention and control:

- Welding, cutting and other "hot work" permit programs.
- A program of supervision for impairments to fire protection equipment using AXA XL Risk Consulting's "RSVP" program.
- Smoking regulations.
- Plant security and surveillance.

Construction

Use only noncombustible construction. Wherever combustible liquids are handled, fireproof building and equipment supports in accordance with PRC.2.5.1.

Sprinklers

Install sprinklers throughout in accordance with PRC.12.1.1.0 and NFPA 13. Where combustible liquids are handled, install Extra Hazard, Group 2 designs. Other areas should be considered Ordinary Hazard, Group 2.

Water Supplies

Install water supplies in accordance with PRC.14.0.1.

Specific Areas

Raw Materials

Protect outside oil feedstock storage tanks according to PRC.17.3.4. See also PRC.2.5.1, PRC.2.5.2 and PRC.2.5.3.

Since feedstock tanks are usually heated, check tank bottoms for water at least daily to avoid boilover or steam explosions. Include the tank heater system on preventive maintenance and nondestructive testing schedules.

Analyze feedstock samples daily to avoid contamination of finished product by processing off-specification material.

Install appropriate classified electrical systems around tank farm pumps per NFPA 70.

Reactors

Protect reactor areas according to PRC.12.2.1.2. Protect control rooms according to PRC.17.10.

Install classified electrical systems as required by NFPA 70.

Design reactor fuel trains and combustion control systems in accordance with NFPA 86.

Gas

Provide Emergency Shut Down (ESD) systems for off-gas, natural gas and acetylene handling equipment. Arrange the ESD systems for manual activation as well as by combustible gas detectors installed in gas handling areas.

Design gas fuel trains and combustion control systems in accordance with NFPA 86.

Construct off-gas ducting of noncombustible materials. Install oxygen analyzers in off-gas handling systems interlocked to activate the ESD system if sufficient oxygen is present to pose an explosion hazard.

Install classified electrical systems as required by NFPA 70.

Bag Houses

Locate bag houses outside of buildings. Provide explosion venting in accordance with NFPA 68. Use noncombustible bags. Install classified electrical systems as required by NFPA 70. Keep spare bags on hand. Install sprinkler protection in the bag houses per NFPA 13 using a density of 0.50 gpm/ft^2 (20.3 L/min/m^2).

Dryers

Provide combustion controls in accordance with NFPA 86. If the unit is a rotary type which might overheat and sag in the event of lack of rotation, install a backup diesel engine driver. Provide classified electrical systems per NFPA 70.

Ducts

Protect ducts handling combustible gases or carbon black with explosion relief per NFPA 68 and install automatic sprinklers in accordance with PRC.9.3.2.1. Provide classified electrical systems per NFPA 70.

Warehousing

Protect warehousing in accordance with PRC.10.1.1 and NFPA 13. Keep carbon black storage segregated from all other combustibles such as empty paper bags or empty wood pallets. Separate newly produced carbon black for 24 hrs from “older” carbon back and from all other combustibles in case of spontaneous ignition.

Install ionization type fire detectors over carbon black storage to detect carbon black fires in the early stages. Institute an inspection, testing and cleaning schedule sufficient to keep the detectors operational in this environment.