Fire risk in activated carbon

Odour technical guide 12

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Activated carbon is widely used for emissions and odour treatment. Under normal operating conditions the likelihood of fire is low, however, there are certain circumstances in which fire could occur.

What is activated carbon?

Activated carbon is usually processed charcoal which has a high surface area in comparison with other packing media. It is used in many industrial processes to adsorb organic chemicals including Volatile Organic Chemicals (VOCs) for example as a primary abatement, removing impurities from biogas to protect CHP engines or as a polishing 'tertiary' process. It can be impregnated with a range of different chemicals for specific applications, for instance it is commonly impregnated with 5-10% caustic soda to improve the removal of hydrogen sulphide.

How does it work?

Organic chemicals in an airstream 'stick' to the activated carbon as they pass through it. The size of the carbon filter, concentration of pollutants and the airflow will determine how long the carbon lasts before it is saturated and requires replacing.

How does it catch fire?

Adsorption onto activated carbon is an exothermic process generating heat. For certain classes of chemicals including organic sulphur compounds (e.g. mercaptans), aldehydes, ketones and some organic acids this reaction is more exothermic resulting in the generation of high temperatures.

Under normal operating conditions, the elevated temperatures do not pose a fire risk. When a carbon filter is operated at its design airflow rate, this flow of air dissipates the heat of adsorption meaning that temperatures required to start a fire cannot be achieved.

Risk factors for fire

There are essentially 3 key risk factors:

1. High concentration of VOCs, especially aldehydes, ketones and acetates. VOCs that contain a functional oxygen group such as ketones and acetates, dissociate after initial adsorption causing secondary heating.
2. Grade of carbon used. When activated carbon is impregnated with potassium hydroxide or caustic based materials, these impurities catalyse secondary reactions outlined above and may cause very localised hot spots. Some suppliers are phasing out the use of caustic and replacing these grades with copper impregnated activated carbon because it is less likely to cause these sort of problems.
3. Low airflow rate. The presence of an adequate airflow will dissipate the heat of adsorption. There is a particular risk when a carbon filter is disconnected because it may only take a gentle breath of air to enter the carbon filter to start a fire when other risk factors are present.

What are the circumstances in which fire has occurred?


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During maintenance to reconfigure pipework, a carbon filter was disconnected from the CHP engine leaving the inlet and outlet ports prone to air ingress. CCTV footage showed smoke being emitted from the isolated unit which eventually caught fire causing significant damage to the CHP system and building which is shown in the photo to the left. This caused significant downtime of the digestion process.

A second incident occurred at a gas upgrading plant. They injected oxygen into a carbon filter to increase the life of the activated carbon. Within 24 hours there was a fire in the activated carbon tank.

Fire Safeguards

Carbon filters can be fitted with fire prevention measures such as one way valves, vacuum relief valves and pressure relief valves. However, there generally appears to be little understanding of fire risk and it is therefore not clear how widespread fire prevention measures are understood or have been implemented.

What information should be requested from operators?

As a minimum we would expect the following:

The operator should be able to demonstrate adequate design of the carbon filter. Assessment of pre-treatment requirements, grade of carbon, proposed airflow, composition of the airstream and residence time can used to estimate the required size of filter.

It is important that the operator can demonstrate how they monitor the effectiveness of the carbon filter to determine when the carbon needs replacing. This can be done by testing the carbon itself or monitoring the outlet gas. A Drager tube could be used for this purpose subject to appropriate assessment.

The operator needs to demonstrate what other monitoring is in place for the inlet / outlet gases, visual checks, airflow rate and residence time. Temperature monitoring may not be sensitive enough to detect localised changes in temperature whereas carbon monoxide monitoring is a much better early indicator.

The operator should demonstrate that they understand the risk of fire and outline what fire prevention measures are in place for the activated carbon filter, especially during maintenance and/or downtime.

References

IChemE Symposium Series No. 141 – Thermal stability of activated carbon in an absorber bed

OSHA Hazard Information Bulletins – Fire hazard from carbon adsorption deodorising systems

Air & Waste Manage. Assoc 51:1617 – 1627 – Carbon bed fires and the use of carbon canisters for air emissions control on fixed-roof tanks

CPL Carbon link - Operating Guidelines For The Reduction of Fire Risk in Systems Utilising Activated Carbon

Further information

For further information, please contact Andrew Lyon, E&B Advisor