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Health and Environmental Issues Associated with Exposure to Pulverized Fuel Ash

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Abstract

Employees of coal-fired power stations and people living nearby as well as those involved in the shipment and processing of coal fly ash can be exposed to coal fly ash (pulverised fuel ash or "PFA"). An extensive research program was carried out in order to map such exposure and its effects. Particle size distribution, chemical composition, quartz, radioactivity, emission factors and fugitive dust modelling were studied.

CFA is a combustion aerosol, which means that the elements which volatilise during combustion are found mostly on the outside of the particles. Particle size is thus dependent on the concentration of these elements. Occupational limits (TLV's or PELs) generally refer to the inhalable fraction (PM50). Based on more than twenty years of research at Dutch coal-fired power stations, it appears that there exists a relationship, the so called RE factor, between fuel composition and ash composition. For all the elements studied RE factors have been determined: for the total CFA, as well as for the inhalable CFA and the respirable CFA. This relationship is incorporated in the KEMA Trace Model®, which also enables the ash composition in case of co-combustion to be calculated.

The occupational threshold values for nuisance dust apply for CFA. This has been determined using the KEMA Dust Assessment Methodology (KEMA-DAM®). In this methodology CFA is interpreted as a mixture of components. The exposure of each individual component is calculated assuming the maximum allowable exposure of inhalable nuisance dust. If the concentration of each individual (trace) element is less than half of its allowed TLV and the concentration of each potential carcinogenic component is less than 0.1%, then the CFA can be regarded as a nuisance dust. So far all the CFA produced, including through co-firing up to 30% (m/m), meets this standard.

Besides trace elements, the occurrence of quartz, radioactivity, PAH and Dioxins is studied in depth. It appears that their occurrence is such that CFA still can be assigned as nuisance dust. For quartz it will be discussed in more detail. In Dutch power stations, when coal is fired, approximately 50% of the quartz is vitrified. This vitreous material is one of the main components of coal ash. The remainder of the quartz finds its way into the pulverised fuel ash in non-vitreous form. Most of this quartz is found in the non-respirable fraction of the ash; the respirable fraction contains only about 1% of the quartz.

In absolute terms, quartz accounted for roughly 0,1% of the respirable fraction of the coal ash samples tested. Between 60 and 86% of this quartz was embedded in the ash particles and therefore not available at the surface. Thus, only a very small amount of the quartz is biologically available.

In the work area directly underneath the E-filter, the measured stationary respirable atmospheric quartz concentrations under normal stationary conditions average 0,0005 milligrams per cubic metre. That is less than 1% of the TLV for quartz, which is 0,075 milligrams per cubic metre.

All the research undertaken, including epidemiological, in vivo and in vitro studies, indicates that quartz in coal ash does not have the same effect on humans or animals as pure quartz or some quartz containing substances and does not constitute a fibrogenic risk. How-ever, exposure to respirable pulverised fuel ash in concentrations of more than 5 milligrams per cubic metre can result in functional impairment of the lungs and respiratory complaints. At even higher concentrations, there is a risk of chronic bronchitis. However, these effects are what one would expect from any particulate material (nuisance dust); they are not specific to coal ash and are certainly not attributable directly to the presence of quartz in the ash.

The absence of the effects normally associated with quartz is attributable to the fact that the quartz in pulverised fuel ash is mainly enclosed within vitreous material. This has been established by electron microscopy of roughly eleven thousand cross-cutted pulverised fuel ash particles. Moreover, it appears that quartz loses its fibrogenic properties when heated to temperatures of more than 1200 oC. All coal ash particles undergo heating in excess of this level.