Health Impact Review on the Proposed Cement Silo at the Kordin Terminal

Dr Ramiro Cali-Corleo MD MSc

January 2014

TABLE OF CONTENTS:

Introduction

The aim of this review is to highlight the potential health risks associated with the loading, unloading and storage in silos of Portland cement in order to enable the Contractor to properly understand the potential health consequences involved and also to recommend mitigating measures with the aim to reduce any health risk to employees and third party individuals to permitted levels. Quantification of this risk was not possible because of absence of sufficient data on both the proposed operation and the medical knowledge of the health effect itself.

Background

Portland cement consists of a crystalline powder and is produced by crushing and grinding calcareous materials (e.g. limestone, chalk) and argillaceous materials (e.g. clay, shale) as a wet slurry or in a dry state. The mixture is calcined in a rotary kiln and the resulting clinker is finely ground. It contains trace amounts of naturally occurring, but potentially hazardous, chemicals including metals such as chromium, nickel, cadmium, lead and crystalline silica. It also contains added supplementary materials such as fly ash or ground granulated slag.

The cement industry is involved in the development of the structures of this advanced and modern world but generates dust during its production and use and this adds to the dusty environment millions of people are working daily in. This exposure to different types of health hazards such as fumes, gases and dust, increases the risk factors of impacted populations in developing occupational disease. Cement dust is known to cause lung function impairment, chronic obstructive lung disease, restrictive lung disease and pneumoconiosis. Many studies are also showing associations with carcinoma of the lungs, stomach and colon. Other studies have indicated that cement dust may enter into the systemic circulation and thereby reach all the organs of body and affecting different tissues including the heart, liver, spleen, bone, muscles and hair, ultimately affecting their micro-structure and physiological performance.

The main constituents and their typical declared percentage in Portland cement are:
Cement Clinker 20-95%
Gypsum 0-5%
Calcium Oxide 0-3%
Fly ash (Where applicable) 8 - 50%
Ground Granulated Blast Furnace slag (where applicable) 8 - 80%
Limestone ($CaCO_3$) 0 - 5%
Hexavalent Chromium Cr (VI) (Cement) <20 ppm (depending on legislation restrictions and technology used)
Crystalline Silica (Quartz) <1-10%

Of the listed constituents, hexavalent Chromium (Cr (VI), which is quite frequently present in cement, is one of the main health concerns. The sources of chromium in cement are the raw materials themselves as well as leaching into the product from the refractory bricks in the kiln and from chromium steel grinders.
Because of concerns about Cr (VI) skin sensitisation, several countries have introduced measures to limit the amount of Cr (VI) in cement products. The European Commission has

already introduced and enacted legislation to restrict the marketing and use throughout the EU of any cement product containing soluble Cr (VI) at a concentration of more than 2 ppm.

The Mamo report also highlights other compounds of concern. Calcium oxide has indeed been described in the medical literature as an irritant even in small amounts and this is treated in this study when discussing the caustic effect of cement. Aluminium oxide is already significantly present in the food chain and the water supply and it is unlikely that anything other than a significant contamination of the grain with cement dust will alter the aluminium level in food produced by this grain to unacceptable levels.
The presence of heavy metals such as the mentioned Cadmium and Lead in cement dust would be certainly a significant concern because of the accumulative properties well described in the Mamo report if the levels present are such that even very minor ambient air contamination from fugitive cement dust will result in an identifiable change in the heavy metal content of the impacted grain. One must note however that the Mamo report quotes cement dust levels of 9.7ppm for Cadmium and 287ppm for Lead while the cement being handled, according to the analysis document supplied and attached to this report shows significantly lower levels of 0.2ppm for Cadmium and 50.07ppm for Lead

Cement dust exposures when studying respiratory health risk have been expressed in the different studies either in terms of respirable dust or as total dust and in a few studies both are listed and taken into consideration. It should be noted that "total" and "total inhalable" dust are not equivalent, "total dust" is measured using the NIOSH method that involves a 37 mm closed face cassette. This is known to under sample for "inhalable dust" as measured using the IOM sampler which has a 25 mm forward facing cassette. Therefore, it is likely that the "total" dust levels reported in some of the studies on cement dust refer to measurements taken with the NIOSH method, and the results will not be equivalent to other studies using the "total inhalable dust" method. This means that the exposure data reported in the studies listed below need to be interpreted with care.
However in many expert views, given that cement dust is very fine, it is reasonable to expect that a high proportion of the total dust created during silo operations will be respirable especially when considering that the cement dust of concern in loading, unloading and storage situations will mainly be fine airborne 'fugitive' dust.

The evidence-base indicating that occupational exposure to dusts in general leads to an increased risk of COPD is well established. Cement dust also happens to be a particularly alkaline and irritant dust and might therefore be considered to pose a greater risk of respiratory tract damage than many other dusts that are much less soluble and generally considered low toxicity dusts.

Up to the present time, a causal association between Portland cement exposure and cancer has not been established. However, the findings of a number of recent studies have increased concerns regarding a possible risk of cancer following long term cement dust exposure. A number of relevant cancer cohort and case control studies have been published in the last two decades, conducted in groups exposed to cement either through employment in cement factories or in the construction industry, that seem to demonstrate increased incidences of cancers at several sites (stomach, lungs, colon, pharynx and larynx) even though one must take into account the limitations in the strength of the observed associations.

There are at present no studies that show any association between contact with cement products and reproductive toxicity and mutagenicity so these have not been considered.

No specific studies or other forms of health information have been found during the literature review for this report that mention any significant health risk in the consumption of food products that have very minor contamination with cement dust. However, because of the presence of potentially toxic minerals, such contamination of grain or any other food product, if it exceeds the permitted tolerances, will most likely render the product unfit for human consumption as a result of failure to conform with the required EU and National food standards and regulations.

Literature review – health outcomes to exposure to cement.

There is little literature available that specifically and solely discusses cement transportation, handling and storage. However there is quite a significant amount of health related literature concerning cement operations in general and the health risk associated with it. The discussion below has referenced only those parts of such documents that are relevant to cement transportation, handling and storage. It is obvious that where the health impact of cement dust is concerned, it does not make a difference if the exposure to cement dust is during its manufacture, while it is being transferred to a storage area, from fugitive emissions from storage, during transportation or during its use in construction, what counts is the level and duration of the exposure. One must note at this point that the risk assessment of the cement operation in question issued by Resolve Consulting defines the exposure risk as low. One must also note that the report on Air Quality of the area before the start of the cement operation issued by AIS Environmental already shows that the air pollution on numerous occasions exceeded the permitted limits and, while there is a clear need for the already existing polluting activities be examined with the aim of improving the said operations in order to mitigate their effect on air quality, any addition, however small, to the pollution in the area by another operation will only make worse the already bad situation.

1. Effects of an isolated/single exposure

Respiratory

Only one recent study looking at the short-term effects of cement exposure was identified. Ali et al in 1998 studied the changes in pulmonary function in workers during a work shift at three Portland cement factories in Saudi Arabia. All areas (including administrative) were represented and the proportion of smokers, ex-smokers and non-smokers was similar in both the study and the control group. Respirable dust was measured using a gravimetric method for a total of 97 samples collected from various areas. Spirometry was conduced immediately before and after the morning shift. The highest values from three acceptable expirations for FEV1, FVC and FEF25-75% were recorded and the FEV1/FVC ratio was calculated. The geometric mean concentration (± SD) of respirable dust ranged from 20 ± 1 $mg.m^{-3}$ in the quarry to 7 ± 2 $mg.m^{-3}$ in the kiln area. Reductions in FEV1, FEV1/FVC ratio and FEF25-75% occurring during the workshift were significantly greater in the exposed workers. The results of this study suggested that the cement workers, who were exposed to relatively high dust concentrations, had suffered bronchoconstriction. While there is clearly a transient health impact shortly following the inhalation of cement dust, the medium to long term health significance of this effect is not known.

Sensitisation

Fleetwood and Soutar in their review of the scientific literature published in 1979 demonstrated that there have been many cases of cement dermatitis believed to be the result of skin sensitisation to hexavalent chromium (Cr(VI)) in mainly wet cement. The National Institute of Occupational Health of Norway conducted a detailed critical review of the literature in 2003 and identified twenty four papers published between 1975 and 2001 specifically studying chromate allergy in humans particularly involving construction workers. Although all the studies were considered to have significant limitations, notably because of the absence of exposure characterisation, problems with differential diagnosis, subject selection bias and the lack of follow-up, the reviewers did identify a consistently high prevalence of Cr(VI) allergy in studies involving construction workers. Also, in the general population studies the prevalence of allergy was found to be higher in construction workers than in other occupational groups. Other studies of patients attending dermatology clinics with a diagnosis of chromate allergy revealed a high proportion of patients with occupations involving contact with cement.

The European Commission's Scientific Committee on Toxicology, Ecotoxicology and the Environment now called the Scientific Committee on Health and Environmental Risks also carried out a selective review of the published literature and concluded that Cr(VI) compounds in cement induce sensitisation and cause serious allergic reactions in construction workers. Also they concluded that water-soluble Cr(VI) compounds penetrate the skin to a much greater extent than the less water-soluble Cr (III) compounds, and that Cr(VI) readily penetrates wet leather gloves. On the basis of this and on studies in Denmark by Avenstorp published in1989, 1991 and 1992 showing that a reduction of Cr(VI) compounds in cement to less than 2 ppm will reduce the prevalence of allergic cement eczema in workers, and will reduce the risk of becoming sensitised to chromate, the European Commission introduced new legislation, through an amendment (2003/53/EC) to the Marketing and Use Directive (76/769/EEC), to restrict the marketing and use of cement and cement containing preparations where the level of soluble Cr(VI) is more than 2 ppm.

Irritation

Cement has irritant and corrosive properties, especially when wet, towards the skin and its high alkaline nature will produce irritation even if a small amount of dust gets into the eyes. These properties of cement are well established and published in medical textbooks but should be easily prevented through the proper use of personal protective clothing and equipment so no evaluation of the literature has been conducted for these adverse health effects in this report.

2. Long term/repeated exposure

Non-malignant

There is significant evidence that repeated occupational exposure of humans to Portland cement dust has produced deficits in pulmonary function, noticeable changes on chest x-rays, chronic productive cough and rhinitis. This is well demonstrated in the great majority of the studies recently carried out as represented by the following:

Yang et al. (1996) administered a respiratory questionnaire and conducted spirometry on 412 Taiwanese cement factory workers. They were exposed to mean respirable dust levels of about 4 $mg.m^{-3}$. The prevalence of respiratory symptoms was higher and FVC and FEV1 were reduced, in comparison with controls.

Mengesha et al. (1998) administered a respiratory questionnaire and conduced spirometry and peak flow measurements in 53 Ethiopian cement factory workers. Current dust measurements were available. There was a higher prevalence of respiratory symptoms among cement workers, compared with controls. FVC, FEV1 and FEV1/FVC ratio were lower for the group with the highest dust exposures.

Alvear-Galindo et al (1999) administered a respiratory questionnaire to 425 Mexican cement factory workers. A semi-quantitative dust exposure assessment was conducted. The prevalence of respiratory symptoms was highest among those with the highest exposures

Noor et al. (2000) investigated 62 Malaysian cement factory workers. A respiratory questionnaire was administered and spirometry was conducted. Current dust measurements were available. There was a higher prevalence of respiratory symptoms and a reduction of FVC, FEV1 and FEV1/FVC ratio among the cement workers compared with controls that were university staff or students.

Meo et al. (2002) conducted spirometry in 50 Pakistani cement mill workers. No information on dust exposure levels was available. FVC and FEV1 were reduced and FEV1/FVC ratio was increased for the cement workers, in comparison with matched controls.

Laraqui Hossini et al. (2002) investigated the respiratory health of 280 Moroccan cement factory workers by respiratory questionnaire and spirometry. No dust exposure measurements were taken, but levels were described as being relatively high. There was a higher prevalence of respiratory symptoms and minor spirometry deficits among the cement workers, compared with controls.

Mwaiselage et al. (2004) studied 115 Tanzanian cement factory workers. Pulmonary function was investigated by spirometry and peak flow measurement. Current total dust exposure measurements were available, from which cumulative exposures were estimated. Lung function was poorer in the occupational goups with current mean dust exposure of 3.2 $mg.m^{-3}$ and above (cumulative dust exposure 36 $mg.m^{-3}$ year and above).. The risk of developing a notable obstructive impairment, represented by a FEV1/FVC ratio <0.7, was significantly increased for cumulative dust exposures in excess of 300 $mg.m^{-3}$ year.

However not all of the studies were negative in outcome and some studies did not show any significant health effect. Examples are:

Abrons et al. (1998) conducted chest radiography in 2640 US cement factory workers. Information on current dust exposure levels was available. A slight increase in the prevalence of minor pulmonary radiographic abnormalities, which seems to be confined to current smokers, was observed for the cement workers in comparison with blue collar controls. Very few of the cement workers had radiographic findings that were indicative of significant pulmonary disease.

Fell et al. (2003) conducted a retrospective cohort study in 119 Norwegian cement factory workers. A respiratory questionnaire was administered and spirometry was conducted. Current dust level measurements were available and a semi-quantitative cumulative exposure matrix was developed. The study showed no differences in the respiratory health of the cement workers exposed to average respirable dust levels of at least 1 $mg.m^{-3}$ when compared with matched blue-collar controls

Mortality

It is the opinion of the experts and the health and safety authorities of developed countries based on the studies and reports currently available that there is no evidence linking occupational exposure to cement with increased mortality, particularly where non-malignant disease is concerned. There is still uneasiness where malignant disease is involved as although there is as yet very little evidence available and certainly not near enough to reach any firm conclusion, there is sufficient to raise concerns. Malignant health effects will be discussed below.

Malignancy

There is as yet no significant and convincing evidence for an increased incidence of any site-specific cancer resulting from cement exposure, but leading health and safety authorities acknowledge that the data available at this time is not consistently and reassuringly negative. In the last 30 years there have been a number of relevant cancer cohort and case control studies, conducted in groups exposed to cement either through employment in cement manufacturing or in the construction industry. These studies have identified associations between cement exposure and cancers at several specific sites: the stomach, lungs, colon, and head/neck. This has resulted in an increased support for the official recognition of a causal association of each of these cancers with Portland cement exposure. Some of the studies suggesting such a relationship are highlighted below:

Maier et al. (1991) investigated the occupational risk factors for cancers of the oral cavity, pharynx and larynx in 200 cases and 800 controls. The study reported an elevated risk of cancer associated with occupational exposure to cement. The estimated RR was 2.4 (95% CI not stated) after adjustment for smoking and alcohol consumption. Mayer and his team obtained similar results in their later studies in 1992, 1994 and 2002

Jakobsson et al. (1993) investigated mortality and cancer morbidity in about 2400 Swedish cement factory workers. Overall mortality and cause-specific non-malignant mortality for the cement workers were similar to the national rates. However, the analysis of individual tumour sites revealed an increased risk of tumours of the right side of the colon (SIR 2.7, 95% CI 1.4 - 4.8, 12 cases). The risk was increased among those with more than 25 years cement plant work. As an extension to their 1993 study, Jakobsson et al. (1994) re-analysed mortality and cancer morbidity for the 1520 Swedish cement factory workers. Comparisons with other groups of blue-collar workers and with the general population were conducted. An increased risk of cancer of the right side of the colon (SIR 2.6, 95% CI 1.4 - 4.6) for the cement workers was confirmed.

Rafnsson et al. (1997) investigated cancer in 1172 Icelandic cement masons. The study revealed an increased risk of lung cancer among the masons in comparison with the general population of Iceland (SIR 1.7, 95% CI 1.1-2.5). The SIR was increased when the analysis allowed for a latency period of 30 years from the start of work as a mason.

Smailyte et al. (2004) investigated mortality and cancer morbidity in 2500 Lithuanian cement factory workers. There was an increased incidence of lung cancer among cement workers (SIR 1.5, 95% CI 1.1-2.1) compared to the general population, but smoking was not taken account of in the analysis. A dose-related trend towards an increased incidence of stomach cancer was observed, although the number of cases was small.

Dietz et al. (2004) investigated the occupational risk factors for cancers of the larynx in 257 cases and 769 population controls. An elevated risk of cancer associated with occupational exposure to cement was reported. The OR was 1.18 (95% CI 0.77-1.18) assessed by substance questionnaire or 2.04 (95% CI 1.16-3.56) assessed by job specific questionnaire, after adjustment for smoking, alcohol consumption and socioeconomic status.

Other studies did not demonstrate any such relationship. The following study is one such example:

Vesbo et al. (1991) investigated cancer morbidity in 546 Danish cement factory workers. No evidence of an increased risk of cancer was reported, when compared with a control group drawn from the local population.

One also needs to take into consideration biological plausibility. As a highly alkaline substance, cement can cause irritation at sites of contact, such as the mouth, throat, oesophagus, stomach and lungs and such persistent chronic irritation will cause repeated cycles of cell death, cell proliferation and other inflammatory responses. It is medically recognised that this process can be a step on the pathway to cancer and so it is biologically plausible to hypothesise that cement dust could have the potential to cause cancers at sites of contact.

The Mamo report justly highlights that not all human receptors are equally sensitive to the constituents of cement and that children in particular are more at risk than adults from the short term as well as the accumulative effects of heavy metals and other health relevant contaminants.

Project description

The Contractor, UC Limited, has constructed a cement silo at Laboratory Wharf, Kordin covering an area of approximately 650 square meters not including the loading/unloading area and the administrative buildings.
It has been declared that cement will be delivered to the site by sea in completely sealed bulk cement carriers. These will berth alongside the quay and pneumatically unload the cement into the silos. The cement will be consequently unloaded using enclosed screw conveyors into road bulk carriers for distribution.
A more detailed description and flow chart of the planned activity can be found in the accompanying Risk Assessment Report by Resolve Consulting and in the Air Quality Monitoring Report by AIS Environmental. No details are given on the expected project life.

Scoping

The identification of potential impacts has been carried out by referring to the published guidelines made available by national regulatory bodies and reference works written by international experts in the field as well as through the review of similar or related projects carried out in other countries and the strategic, environmental and health impact assessments carried out on them. It is understood that all the construction has been completed and so only impacts related to the operational phase will be tackled in this report.
The areas of concern relevant to the Kordin cement silos are sea water contamination issues, occupational health and safety issues, road usage and traffic flow, adjacent grain handling operations, waste water drainage/disposal, issues associated with anticipated operating hours

for transportation (internal transportation at site, delivery and outward transport of product), noise and light issues and air quality concerns.

Relevant Legislative framework

As already stated by AIS Environmental in their Air Quality Monitoring report for this project, the relevant legislations at European and National level are:
Directive 2008/50/EC that is transposed in the Maltese legislation through *L.N. 478/2010*
Directive 2004/107/EC that incorporates the following previous directives, namely the Air Quality Framework Directive (Directive 96/62/EC) and its daughter directives 1999/30/EC, 200/69/EC and 2002/3/EC which are also transposed in the Maltese legislation through *L.N. 478/2010*
Directive 2004/107/EC relating to Arsenic, Cadmium, Mercury, Nickel and Polycyclic Aromatic Hydrocarbons in ambient air which is, as stated by AIS, in the final stage of the process launched by framework Directive 96/62/EC in revising the European legislation regarding pollutants posing a risk to human health. The Directive applies the principle of lowest possible exposure to any substance where a clearly identified 'safe limit' has not yet been identified by science. The directive does not set limit values for emissions of Polycyclic Aromatic Hydrocarbons (PAH), but uses Benzo(a)pyrene as a marker for the carcinogenic risk of these pollutants and sets a target value for that substance to be reached.
The Directive also determines methods and criteria for assessing the concentrations and deposition values of the substances in question in order to ensure that adequate information is obtained and made available to the public.
L.N. 478/2010 also determines the European Norm (EN) that must be applied in Malta for sampling and measuring ambient air pollutants. These norms were developed by the European Committee for Standardization. The EN specifications which have been applied in assessing this project were EN 12341:1999 "Determination of the PM_{10} fraction of suspended particulate matter" and EN 14907:2005 "Standard gravimetric measurement method for the determination of the $PM_{2.5}$ mass fraction of suspended particulate matter"
Also of relevance in this case is the European Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for contaminants in foodstuffs

Baseline environmental conditions

Air quality
The zone in question is an industrial/commercial port and concerns of a residential nature appear not to be relevant thus health concerns are principally of an occupational nature and the potential contamination of adjacent commestables.
The air monitoring studies carried out by AIS Environmental show that baseline air quality in the area of interest has been recorded as already exceeding the permitted limits for PM10 on 6 of the 24 days of monitoring while the levels of PM2.5 almost reached but did not exceed the limits on 5 of the monitored days.

Bodies of water
No baseline data was available

Noise and light pollution
No baseline data was available

Vehicular traffic
No baseline data was available

Predicted impacts

1. Air Quality
The major constituents in dust from cement operations are alumina, silica, metallic oxides and clay, trace amounts of organic chemicals (dioxins and furans), heavy metals (cadmium, Lead and selenium) and radio nuclides.
Dust may be generated during the normal operation of a cement bunkering operation during the loading and unloading of the silos and during the road transport to and from the site. This fugitive dust will increase the particulate content of the ambient air as well as deposit on structures, roads, vehicles and non-sealed goods and materials in the impacted area. There is also the possibility of cement dust escaping as a result of a system/equipment failure.
Cement dust contamination resulting from a leak due to equipment failure or human error has been predicted in the Risk Assessment Report by Resolve Consulting as being Low Risk as long as the recommended strict maintenance regime is maintained.

However, all of the impact reports on cement production, cement handling and storage operations reviewed have shown that it is not possible to eliminate all fugitive cement dust emissions. These emissions, even following best practice and even if in individually negligible quantities, occur repetitively every operational day, throughout the year, and include settled cement dust on roads becoming airborne again due to vehicular movement and human activity. Airborne dust does eventually settle on the ground, maybe after a longish airborne phase, depending on its particle size, wind direction and velocity etc. This dust gets airborne again and again, every time movement of wind or vehicles disturbs it, increasing the area affected as dust emitted from one area, gets airborne and settles in another area, some distance away. It again gets airborne after some time and settles in some other area even further away from the original source causing unnecessary air pollution.

One needs also to take into consideration that cement dust contains considerable amounts of very fine particles which will tend to disperse over much greater distances from the source. PM10 has a relatively fine particle size range not overly susceptible to gravitational settling and has been shown to settle even a hundred meters and more from the site of release. The Kordin grain terminal is within 100 meters of the new cement silo operation and since the grain terminal is east to the cement operation it is also downwind where the prevalent winds in Malta are concerned and more likely to be impacted from any fugitive cement dust especially since the usually recommended 100m buffer zone from sensitive receptors is not present This means that PM 10 and even more 2.5 cement dust particles (the main constituent of fugitive cement dust) that escaped days before may deposit on grain being transferred days later. The accurate prediction of additional dust impacts arising from this project is very difficult given the changing natural dust levels that already exist in the location which have been shown to regularly exceed the permitted limits. The Contractor will need to be very vigilant and constantly monitor the air quality in the area of operations using effective point source emission control practices and be prepared to modify the applied mitigation factors to ensure that the required occupational health and safety standards are maintained and any impact on third parties minimised to permitted levels.

2. Water contamination
The existing condition of the seawater or fresh water in the impacted area may be changed as a result of cement dust contaminated run-off from wash-down areas, roads and during cleaning and maintenance operations. Any effect on land and marine flora and fauna is beyond the scope of this report and as there are no designated bathing areas within the potentially impacted zone, concerns regarding bathing area contamination and related effect on human health seem not present.

3. Noise
The potential sources of noise associated with such a development need to be identified. These are likely to be operational noise (e.g. from vehicle movements and from operation of the conveyors). If these are likely to be significant for particular receptors and resources, an assessment will need to be made for the planned operational hours including relevant meteorological and topographical factors, and existing major sources of noise and appropriate mitigation measures applied

4. Traffic
A traffic impact study should be carried out for heavy vehicle movements, on staff vehicle movement and boat navigation in order to estimate the effect on air quality from exhaust gases and dust generation as well as on noise levels

Mitigation measures

The implemented mitigation strategy, including the consideration of alternative opinions, and the extent to which this will avoid or reduce significant effects should take into account its sustainability, integration, feasibility and compliance with statutory obligations under any required licences, permits or approvals.
The mitigation strategy the Contractor should adopt must outline the environmental management principles to be followed in the planning, design, establishment and operation of the proposed development. It should include specific locational, layout, design or technology features and an outline of ongoing management and monitoring plans.
These mitigation and management measures are being recommended to control the predicted health impacts

Control, treatment and proper disposal of liquid effluent and runoff
It is an internationally required practice that all washing water and rainwater will be collected and retained on-site until properly treated and disposed of. No water should be discharged outside the plant boundary and this includes rain water. There should be regular cleaning out of solids that may accumulate in the holding tank/pit. The storage capacity must be sufficient to store the maximum possible run-off generated over a 24 hour period

Air quality
A regular monitoring program of the air quality at the site as well as at other sensitive third party sites must be carried out. Monitoring of possible cement dust contamination affecting sensitive receptors such as the grain and its loading and unloading machinery at the adjacent grain handling facility should also be carried out. The other operations in the zone of concern, including the grain handling operation, should be reviewed to ascertain their contribution to the already poor air quality in the area and any sources of air pollution identified should be mitigated appropriately.

Control of fugitive dust emissions

Dust collection and filtering system should be the best available and rigorously maintained to the manufacturer's specifications. It is recommended that dust collectors will be sized to exceed the predicted worse case requirement and fitted with burst bag detectors connected to the automatic silo overfill protection circuit. Filters should be cleaned, ideally automatically, at the end of the silo filling operation and should be able to withstand the maximum possible pressure differential

Pressure relief valves should be regularly inspected and should be ducted to a container on the ground capable of effectively collecting and containing all dust particles.

The exhaust air from the silo filters should be ducted to a dust collection system on the ground. Exhaust discharge points must be visible and monitored during the silo filling operations in order to immediately stop the filling of the silo should any fugitive dust be noted.

An emergency shutdown valve should be fitted as close as possible to the silo outlet point to ensure cement release can be rapidly stopped should a ducting joint fail

A regular inspection regime should be in place for all dust control components ensuring all duct work is airtight and appropriate lighting should exist at all operational times to permit rapid visual identification of any fugitive emissions.

Natural and artificial wind barriers should be employed where possible but particularly around the loading/unloading areas to help control the spread of dust emissions.

The silos should be equipped with pressure sensors and high level alarms with automatic delivery shutdown switches set to ensure no accidental overfilling occurs.

The paving of the entire silo compound, including all entrance/exit roads, should be with hard impervious material that must be kept clean and dust free through the use of vacuum sweeping of the site itself and watering of the road surfaces at regular intervals during and following loading and unloading operations. Any spills must be cleaned immediately.

There should be on-site vehicle speed control with all vehicles on site not exceeding 20km/hr and to avoid dust stirring under wheel action. All vehicles should receive a wheel wash designed to account for the maximum extended tyre length expected and with a sufficient track-out distance from the entrance/exit. In the event that an episode of fugitive cement dust is identified, there should also be a protocol in place whereby any contamination to third party equipment and goods, in particular foodstuffs such as grain, resulting from the escape is also identified and mitigated appropriately ensuring no health risk to eventual consumers.

Occupational Health and Safety

The Contractor must provide for periodic health assessment of all employees at risk so that any adverse impact on health can be detected as quickly as possible and preventive measures implemented.

First aid equipment will be provided and installed at appropriate locations for immediate response

All the workers and officers working inside the plant will be provided with disposable dust masks, however workers at greater risk will be supplied with industry standard respirators and eye protection as well as ear muffs when there is the risk of exposure to noise levels above 85dBA. Those who may need to handle cement dust contaminated equipment should be provided with waterproofed leather gloves and any other required industry standard clothing.

Although it has been stated that cement handling and grain handling operations cannot be carried out concurrently, one must consider the occupational risk of third party workers who may be affected by any cement dust air contamination that may reach their place of work and

it is essential that provisions to deal with a catastrophic escape of cement dust should also take these workers into the equation.
Proper training of operators will reduce to the minimum the risk of worker injury or illness as well as minimise the chance of significant fugitive cement dust contamination.

Noise

There should be effective means to control the level of noise from any plant and machinery through proper maintenance and if found necessary ensure compliance with relevant standards through sound attenuation measures such as walls, noise adsorbing claddings and encapsulation.

Summary and conclusion

Cement dust is a highly toxic compound however as long as a high vigilance, including regular active air quality monitoring, for fugitive dust is maintained, the declared standards are properly implemented and the recommended mitigating measures applied, the health risk is expected to be within the accepted standards. It is unlikely that this silo operation will be completely free from all fugitive cement emissions and so the possibility that the grain being handled nearby will be subject to a level of contamination from cement dust remains present even following the application of best practices. This is unlikely to be a significant health risk to consumers if monitoring of any contamination to the grain and equipment is carried out should any contamination of the ambient air with cement dust be identified, particularly in the days following loading and unloading of the cement silos and should any grain contamination be identified, rending the grain unfit for consumption, the equipment is to be appropriately cleaned and the affected foodstuff not permitted to enter the food chain. This does obviously involve a pecuniary element and a commercial liability risk which is beyond the scope of this report to discuss.

References

Abrons HL, Petersen MR, Sanderson WT, Engelberg AL, Harber P (1998) Chest radiography in Portland cement workers. J Occup Environ Med, 39, 1047-54

Ali BA, Ballal SG, Albar AA, Ahmed HO (1998) Post-shift changes in pulmonary function in a cement factory in eastern Saudi Arabia. Occup Med (Lond), 48, 519-22

Alvear-Galindo MG, Mendez-Ramirez I, Villegas-Rodriguez JA, Chapela-Mendoza R, Eslava-Campos CA, Laurell AC (1999) Risk indicator of dust exposure and health effects in cement plant workers. J Occup Environ Med, 41, 654-61

Assessment of fugitive emissions & development of environmental guidelines for control of fugitive emissions in cement manufacturing industries. Central Pollution Board (2007) Ministry of Environment & Forests, Govt. of India

European Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs

Cement Safety Data Sheet (2009) CEMEX ESPAÑA S.A.

Dietz A, Ramroth H, Urban T, Ahrens W, Becher H (2004) Exposure to cement dust, related occupational groups and laryngeal cancer risk: Results of a population based case-control study. Int J Cancer, 108, 907-11

Environmental Impact Assessment Guidelines for Cement Manufacturing Plants (2005) Egypt Ministry of State for Environmental Affairs, Egyptian Environmental Affairs Agency EEAA

Fell AK, Thomassen TR, Kristensen P, Egeland T, Kongerud J (2003) Respiratory symptoms and ventilatory function in workers exposed to portland cement dust. J Occup Environ Med, 45, 1008-14

Galdes C. (2011) The Climate of Malta: statistics, trends and analysis 1951-2010. National Statistics Office, Malta

Guidance to prevent over-pressurisation of storage silos (2011) Mineral Products Association Ltd.

Health and Safety Information Portland cement: (BS EN 197-1:CEM I). LAFARGE Cement UK LTD

Jakobsson K, Horstmann V, Welinder H (1993) Mortality and cancer morbidity among cement workers. Br J Ind Med, 50, 264-72

Laraqui Hossini CH, Laraqui Hossini O, Rahhali AE, Tripodi D, Caubet A, Belamallem I, Verger C, Hakam K, Alaoui Yazidi A (2002) [Respiratory symptoms and ventilatory disorders among a group of cement workers in Morocco] French Rev Mal Respir, 19(2 Pt1), 183-9

M. Abu-Allaban, H. Abu-Qudais. Impact Assessment of Ambient Air Quality by Cement Industry: A Case Study in Jordan. *Aerosol and Air Quality Research*, 11: 802–810. 2011

MPA guidelines on cement deliveries (2011) UK Mineral Products Association

M01-EN.Training manual for Risk Assessment in the cement industry. TRIA Project; www.aulbremen.de/triatria/en/en.../en.../en_module_01-00.pdf

Maier H, Dietz A, Gewelke U, Heller WD (1991) [Occupational exposure to hazardous substances and risk of cancer in the area of the mouth cavity, oropharynx, hypopharynx and larynx. A case-control study] German Laryngorhinootologie, 70, 93-8

Mamo J; Cauchi J.P. (2014) Report on a cement silo development. A Public Health Perspective

Mengesha YA, Bekele A (1998) Relative chronic effects of different occupational dusts on respiratory indices and health of workers in three Ethiopian factories. Am J Ind Med, 34, 373-80

Meo SA, Azeem MA, Ghori MG, Subhan MM (2002) Lung function and surface electromyography of intercostal muscles in cement mill workers. Int J Occup Med Environ Health,15, 279-87

Mwaiselage J, Bråtveit M, Moen B, Mashalla Y (2004) Cement dust exposure and ventilatory function impairment: an exposure-response study. J Occup Environ Med, 46, 658-67

Noor H, Yap CL, Zolkepli O, Faridah M (2000) Effect of exposure to dust on lung function of cement factory workers. Med J Malaysia, 55, 51-7

Rafnsson V, Gunnarsdottir H, Kiilunen M (1997) Risk of lung cancer among masons in Iceland. Occup Environ Med, 54, 184-8

Smailyte G, Kurtinatis J, Andersen A (2004) Mortality and cancer incidence among Lithuanian cement-production workersOccup Environ Med, 61, 529-34

Technical Background Document on Control of Fugitive Dust at Cement Manufacturing Facilities (1998) U.S. Environmental Protection Agency

Texas Commission on Environmental Quality (2000) Air Quality Standard Permit for Concrete Batch Plants

UK Health and Safety Executive (2013) Portland Cement Dust *Hazard assessment document* EH75/7.

UK Health and Safety Executive (2002) *HSE information sheet* – Cement.

Vestbo J, Knudsen KM, Raffn E, Korsgaard B, Rasmussen FV (1991) Exposure to cement dust at a Portland cement factory and the risk of cancer. Br J Ind Med, 48, 803-7

Yang CY, Huang CC, Chiu HF, Chiu JF, Lan SJ, Ko YC (1996) Effects of occupational dust exposure on the respiratory health of Portland cement workers. J Toxicol Environ Health, 49, 581-88

CEMEX

ALCANAR PLANT (SPAIN)

AENOR ER Empresa Registrada ER-0051/1998

CERTIFIED IQNet QUALITY SYSTEM

VESSEL: DEMETRIOS

CEMEX España Operaciones S.L.U.

AVERAGE CHARACTERISTICS OF GREY CEMENT TYPE CEM I 42,5 R IN BULK
PRODUCED IN ALCANAR PLANT ACCORDING TO: UNE-EN 197-1:2011
- CERTIFICATE OF CONFORMITY CE Nr 0099/CPD/A33/0769 -

ADDITIONAL CHEMICAL INFORMATION	AVERAGE VALUE	STD
Cd, ppm	0,20	-
Pb, ppm	50,07	-

Note: Trace elements encapsulated in solid solution in clinker phases.

Sign: Jose Luis Saez

CEMEX España Operaciones, S.L.U. CEMEX Partida La Martinenca, s/n - 43530 ALCANAR

Aragon&Cataluña Quality Manager

Date: 20/01/2014