République Libanaise
Bureau du Ministre d'Etat pour la Réforme Administrative
Centre des Projets et des Etudes sur le Secteur Public
(C.P.E.S.P.)

ASSESSMENT REPORT

AIR POLLUTION IN BEIRUT
AN INVESTIGATION OF INDUSTRIAL AIR POLLUTION SOURCES
IN THE VICINITY OF [illegible] AND CEMENT AND CLINKER

[illegible]

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Republic of Lebanon
Office of the Minister of State for Administrative Reform
Center for Public Sector Projects and Studies
(C.P.S.P.S.)

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I INTRODUCTION

1. Origin of the Project

Increasing heavy-industrialization of the North-Western part of the Lebanon brought in its train difficult technical problems of air pollution, especially with the subsequent development of residential areas close to the works. From time to time representations were made to works about their air pollution and some improvements were effected, but these were not sufficient to prevent continued complaints. After discussions and exchanges of letters between the Ministry of Public Health and Eastern Mediterrarean Regional Office of the World Health Organization, agreement was reached that WHO would provide assistance to the Lebanon in the form of a short-term consultant who would give advice about the control of offending industrial emissions. The services were provided from 7 to 13 November 1966.

2. Purpose of the Assignment

The purpose was to visit the major works alleged to be giving offence in the vicinity of the towns of Heri and Chekka, obtain information about the processes, inspect the works and make recommendations, if necessary, for improvement of local conditions.

3. Facilities Available

Mr. Massouh, Engineer for the Mount Lebanon District of the Ministry of Health, accompanied the writer on his visits to works, provided transport and acted as interpreter where necessary.

II GENERAL INFORMATION

The population in the Lebanon in 1958 was estimated at 1 900 000 and in 1963 at 2 200 000.

The area is 4 015 square miles (10 278 Km^2) and it occupies a coastal strip on the eastern limit of the Mediterranean Sea. From the sea, mountains rise gradually to a height of 9/10 000 feet (2 700/3 000 metres). Non-porous layers of rock result in springs appearing at heights of 4/5 000 feet (1 200/1 500 metres) and the hills are well cultivated. Rainfall is about 30/40 inches (750/1 000 mms) at the coast 50 inches (1 250 mms) in the mountains and 15 inches (375 mms) in the eastern part of the country. Rain falls from October to April. Humidity is high. The towns of Heri and Chekka are adjacent and on the coast about 60 km north of Beirut. They lie on a small coastal plain with hills rising steeply

to the south and east and rises gently to the north. On this plain are sited various works including three cement works, a lime and plaster works and a works producing concrete shapes. A short distance to the south at Salaata are two chemical fertilizer works. About 20 km to the north is the city of Tripoli, on the southern side of which a number of industries have established themselves.

III INVESTIGATIONS

1. Discussions with Ministry, Local Government and other Officials

Preliminary talks were held at the Ministry of Health in Beirut with the Director-General, Dr. Anouti, the Director of Preventive Health Services, Dr. Jalloul and Mr. Massouh, in which the main problem was specified as odour and dust from cement works in the Heri and Chekka districts, with emissions often coming to earth rapidly from the works chimneys and causing annoyance and unrest to the residents. The consultant was asked to assess the emissions with a view to making recommendations for their reduction and for the laying down of standards for existing and future plant. At the end of the assignment a further meeting was held with Dr. Anouti, Mr. Massouh and the Chief Sanitary Engineer, Mr. Joseph Andary in which the findings were discussed.

There were further discussions with Dr. Araco and Mr. J. Ibrahim at the Department of Environmental Health, School of Public Health, American University of Beirut, at which they explained their own work on air pollution. Later, an interesting and useful talk took place in Tripoli with Mr. Hallab (former Chief Sanitary Engineer, Ministry of Health) and Mr. Ouayda, Sanitary Engineer for North Lebanon in whose district the offending works were sited. They were able to explain the work already carried out to try and gain improvement.

In a discussion with the Governor of the Sub-district based on Batroun, Mr. Emile Achkar, emphasis was laid on the troubles caused by the chemical fertilizer factories at Salaata, especially the allegation that liquid effluents were responsible for killing fish off the coast.

A visit was paid to the Industry Institute, Beirut, where problems of measurement of pollution were discussed with the Chief Chemist, Mr. Adnan Shaykh, and in particular the help the Institute had given in helping to elucidate the present troubles. A sample of a thick, black residue from the sea shore near the liquid effluent outlet from the Lebanese Chemical Co. Salaata, was left for identification.

A sample of the same residue was left with the Chief Chemist of the Public Health Laboratory, Dr. Stephan, for analysis.

2. Works Visits

The operational details obtained during works visits are recorded fully to help the Ministry officials in dealing with future activities concerning air pollution control:

i. Cimenterie Nationale Ltd., Chekka

Visited: 8.11.66; Meeting with Mr. Hans Lorenz - Works Manager. Produce 1 500 tons/day of cement in three kilns by the wet process with 40/42% moisture.

No. 1. Single rotary kiln producing 250 tons/day[1], chains at back-end, no dust arrestors, 12 years old, chimney 42 m, oil burning with fuel oil of about 3% sulphur. Very little instrumentation and no oxygen indicators on waste gases.

No. 2 and 3. Produce 550 and 800 tons/day respectively. No. 2 being 8 years old and No. 3 only two months. No dust arrestors. Common chimney 50 m. Both these kilns are of a special, double-kiln design and there are said to be only four such kilns in the world. They are designed to cope with raw materials of high plasticity which tend to "ball" and stick in the chain section of a normal kiln. The kiln is divided into two separate parts, the first part of which is heavily chained and rotates at twice the speed of the second part, which is unchained. Between the two parts is a tower and the material passes from the first to the second part by means of a chute. The raw materials are good quality limestone with iron oxide and silica to maintain the calcium carbonate content of the raw meal at 77/78%. Both kilns are provided with excellent instrumentation systems and include oxygen indicators on the waste gases, measured at the tower section and for which the target is 4%. The temperature in the tower is maintained at 750/850°C and in the outlet to the chimney it is 135°C. The clinker grinding mills and packers are fitted with dust arrestment plants and are satisfactory. This works was kept in excellent condition and there was a high standard of technical control. Apart from a few minor dust sources such as the limestone off-loading hopper and the occasional conveyor change-over point, the only disturbing features on this works were the lack of dust arresting plant for the kiln gases and the chimney heights. The chimney plume had a very clean appearance and dispersed well and the claims of the Works Manager that their system produces

[1] Throughout this report quantities are expressed in metric units; the metric ton (= 1 000 Kg) is indicated simply as "ton".

but little dust may well be true. Tests for dust burden should be made on the kiln waste gases before arriving at an opinion about dust pollution from this works and the author recommends that this be done. Mr. Lorenz was interested in dust testing and the writer sent him details via Mr. Massouh of a suitable apparatus, which is covered by British Specification 3 405:1961 and designed by the British Coal Utilization Research Association (See Annex I). It is also recommended that the company should be asked to carry out periodic, say weekly, tests for hydrogen sulphide on the kiln gases (See Annex I Ref. 2). An oxygen content of 4% in the waste gases should ensure complete absence of the offensive hydrogen sulphide, but this needs confirmation. A dust burden of 1 000 mg/Nm^3, measured wet, can be considered just acceptable for an existing kiln although the target should be 450 mg/Nm^3.[1]

When producing cement resistant to sea water at this works, the aluminium oxide component is reduced and iron oxide is increased to the extent of about 4-5 per cent.

The chimneys are substandard for the size of works. They should be at least 60m and 85m, or preferably one common chimney of 90m. New chimneys should be designed for an efflux velocity of 15m/sec. It is doubtful whether a requirement for higher chimneys for existing kilns can be justified, but the subject should be given serious consideration by Ministry and company officers.

ii. Société des Ciments Libanais, Herd

Visited: 8.11.66 and 9.11.66; Meeting with Mr. Jean Asfar - Director-General, Mr. Max Peters, Technical Director and Mr. Khalloaf, Chief Chemist.

Cement production is at the rate of 700 000 tons per year by the wet process from four kilns of which the individual capacities are 90, 120, 150 and 300 tons per day respectively. The kilns were installed in 1935, 1935, 1949 and 1956. Temperature of emission is 250°C. There are four chimneys, each of which is 60m. There are no external dust arresters for the waste kiln gases and the chimney plumes have a pronounced red or grey colour giving poor dispersion. The most modern kiln has a Fuller clinker cooler and the remainder have Smidth integral coolers. Clinker grinding mills and packers are fitted with bag filter units for dust arrestment and are satisfactory. The kiln waste gases are

[1] Concentrations of pollutants are expressed in milligrammes per cubic metre of air at standard temperature and pressure.

fitted with oxygen indicators or recorders and these registered 2-2.5% oxygen, which should be sufficient to prevent hydrogen sulphide formation if maintained at this level. The instruments are said to be checked by Orsat gas analysis once per week.

During the second visit it was stated that when sea water resistant cements are produced, iron pyrites (iron sulphide) is added to the raw materials to the extent of 2.5-3%, i.e. about 4-4.5% on the clinker produced. The extra sulphur from this source may swing the balance from no hydrogen sulphide to some hydrogen sulphide in the waste gases. Certainly the body of opinion seemed to be that the bad odour which led to complaint was caused by manufacture of this type of cement. This may or may not be true, but it is quite unnecessary to use iron pyrites. Iron oxide is equally as effective in making sea water resistant cement and should be used in preference to pyrites. Use of the latter in this context should be banned and this is what the author recommends.

The author and Mr. Massouh were informed by Mr. Asfar and his colleagues that they were embarking on a major programme of expansion and replacement which was scheduled for completion by the end of 1968. This involved the installation of one new kiln of design rating 1 500 tons per day, the retention of the most modern of the existing kilns rated at 900 tons per day and the scrapping of the remaining three kilns. Both units would be fitted with electrical precipitators to a guaranteed dust emission burden of not more than 150 mg/m^3 when measured at the temperature of emission. This is equivalent to about 270 mg/Nm^3. It was said that the decision had been taken to purchase the electrical precipitators and an import licence was being sought. The two kilns would be fitted with the most modern control instruments including oxygen recorders for the waste gases. This is good news and means that a decision need be taken about emissions from the existing kilns, provided the Company goes ahead with its stated plans without delay. No doubt planning permission will be sought for the new project and it is recommended that it be allowed, subject to certain conditions.

The following suggestions are made for these conditions:

a. The performance of the electrical precipitators shall be checked by a routine monthly test to be performed by the

works or on their behalf and the result reported in writing to the Ministry of Health not later than one week after the end of the month. A suitable method of test could be according to BS. 3 405:1961 and the apparatus used shall be that designed by the British Coal Utilization Research Association (See Annex I, Ref. 1). An alternative method and apparatus can be used provided it can be shown to give the same result as the above.

b. A test for hydrogen sulphide shall be carried out on the waste gases from each kiln not less than once per week, or immediately in case of complaint of odour, and the results reported in writing to the Ministry of Health not later than one week after the end of the month. Hydrogen sulphide should normally be absent but a concentration of 5 p.p.m. can be tolerated if the chimney is high enough. The test should be the lead acetate paper methods (See Annex I, Ref.2).

c. The designed efflux velocity from the chimneys at maximum rated capacity shall be not less than 15 metres per second.

d. It is preferable for one common chimney to be used rather than two separate chimneys because the additional plume rise due to thermal buoyancy and momentum helps to promote better dispersion. This is a matter for negotiation with the company and the chimney heights will depend on the firm figures they submit for production rates. On the basis of the information already given orally, a common single chimney should be 360 feet (110 metres). Should the company elect to use two chimneys then a more difficult decision is needed for it can be considered that the chimneys are near enough to each other to constitute a point source and two chimneys each of 360 feet (110 metres) are required. This is a costly item and in view of the high efficiency of dust arrestment it is suggested that two chimneys each of 315 feet (95 metres) be allowed as acceptable. In view of the unfavourable local topography, this is being kind to the company and they should consider it as a good insurance against abnormal incidents.

iii. Société libannise des Ciments Blancs. Chekka

Visited: 9.11.62. Meeting with Mr. Aql, Works General Manager and Mr. Zeenny, Secretary-General.

This works has been making white cement for two years with one kiln by the wet process with 34/35% moisture in the slurry. Rated capacity of kiln is 150 tons/day, but it was only operating at 120/130 tons/day during the visit. The raw materials are good quality limestone blended with sand and imported aluminium oxide. The limestone is reduced to small size first by a primary jaw crusher, then a secondary hammer crusher and finally it is wet ground in a ball mill. Sand is dried from 10-20% moisture down to nil in a rotary, oil-fired dryer and waste gases are de-dusted in a cyclone. The dry sand is ground to powder in an air-swept ball mill from which it passes to a cyclone separator and the air is vented to bagfilters. The wet limestone, dry sand and alumina are mixed and fed into the oil fired calciner. Gas exit temperature 200°C. After leaving the kiln and before entering the 62 metre chimney, the waste gas passes through a vertical chamber in which chains are hung in a dense mass. Some dust is deposited and removed from the base of the chamber. The oxygen content of the gases is controlled between 2 and 4%. The sulphur content of the oil is about 3%. Temperature control is by means of pyrometers placed at the front, middle and back end of the kiln.

The clinker grinding and packing sections are both ventilated to their own bagfilter plants and are satisfactory.

The whole plant was in excellent condition with good instrumentation and technical control. The only disturbing facet was the lack of a first class dust arrester for the waste gases from the kiln. The appearance of the chimney plume was very good and it dispersed well. White cement plants do not operate at the same intensity of production as similar sized Portland cement units and it may be that dust carry-over from the kiln is low. Before a proper opinion about the emission can be formed it should be tested for dust burden and hydrogen sulphide when on full output.

iv. Société des Chaux et Plâtres du Liban, Chekka

Visited: 9.11.72. Meeting with Mr. Khoury, General Manager and President of Board of Directors.

The works is 2 ½ years old and makes lime and plaster. Production rate is 300 tons/day of lime and 100 tons/day of plaster.

a. Lime. There are two oil-fired rotary lime kilns in which calcium carbonate is heated to form calcium oxide for the building industry. Lump limestone is reduced in size to about 3 cms. diameter by jaw crushers and screens, the oversize being returned for further crushing and the undersize being sold to other industries. These units are properly ventilated to air via simple cyclones. The graded limestone is fed from hoppers into the rotary calciners and thence to coolers and waste gases are dedusted in multitubular cyclones before passing to the 43 metre chimney.

Lime is hydrated in a suitable mixer and the dust emission is scrubbed in a water labyrinth in the form of a serpentine fitted with water sprays.

The works was in excellent condition with good instrument and technical control and the writer does not believe that it would cause offense to the neighbourhood when operating normally. It would be desirable to have dust tests performed on the chimney gases to see what level of dust emission is created. The target should be to get below 450 mg/Nm^3, but some flexibility is allowable for an existing works.

b. Plaster. The sequence of operations is gypsum jaw crusher, elevator to silo, conveyor to feed hopper, rotary kiln, primary and secondary grinders, elevator to 6 x 150 tons capacity silos and packers. The rotary furnace is a muffle type oil fired furnace with the gases in closed circuit at 600/650°C, except for a necessary small bleed to air via cyclones. The crusher and primary and secondary grinders are fitted with simple cyclones and the packers with four cyclones. The plant was undergoing its major annual overhaul during the visit, but it was obviously a first class unit with proper instrumentation and technical control. The writer does not consider this plant will be a major contributor to local dust nuisance, but a further assessment needs to be made by the local inspector when the plant is in full operation.

v. Lebanese Chemical Co. Salaata

Visited: 10.11.66. Meeting with Mr. Joseph Doumet, Director-General (acting) of plant and production, Mr. Sebastian Nichiaricho, Director-General and Mr. Vols, Chemical Engineer.

At this works sulphuric acid and superphosphate are produced.

a. Sulphuric Acid. There are two contact sulphuric acid plants operating at 80 and 100 tons/day and a third is under construction to make 200 tons/day. The acid plants are of the company's own design and construction, with 4-pass catalyst systems. The existing units are sulphur-burning, but the third unit is designed to burn either sulphur or iron pyrites. The chimneys are 20/23 metres above ground level. The acid plants are in excellent condition and there is good instrumentation and control. Efficiency of conversion is said to average about 98.3%. The company relies on this efficiency test as a measure of its omission, but it is recommended that they also carry out a simple test for acidity on the chimney emissions, say once per week. A standard of emission of not more than 2% of the sulphur burned should be considered satisfactory. (See Annex I, Ref. 3).

The plans for the new unit were examined and it was pleasing to note the incorporation of an internal acid-droplet arrester in the top of the final absorption tower. Omission of an arrester can lead to much justified complaint.

As with many other contact acid plants it was noted that manufacture of 20% oleum (sulphur trioxide dissolved in 100% sulphuric acid) caused an acid mist to be emitted, whereas production of 98% acid gave an invisible plume. These acid mists can be unpleasant if very pronounced, but the slight mist seen did not warrant any action.

It is recommended that any new contact acid plants should be built with a minimum chimney height of 35 metres. The recommended chimney height for the 200 tons/day unit is 40 metres and it may be possible still to negotiate this height with the company if firm orders have not yet been placed and the foundations laid. Gas velocity in the chimney should be restricted to not more than 9 metres per second to avoid physical entrainment of acid drops from the wet wall, but the top of the chimney should be restricted by a truncated cone shape to give an efflux velocity of about 15 metres/second to avoid downwash.

b. Superphosphate. Phosphate rock is received and stored in powder form and contains about 4% of fluorine. Sulphuric acid and phosphate rock are fed continuously into a mixing tank at the entrance to a Montecatini rotary drum superphosphate unit. The almost-dry mix is discharged and taken to the storage bay where it is allowed to mature for several days before despatch to customers. The noxious gases from the rotary drum are extracted to a conditioning tower where they are given an initial spray with water. The potent fraction of the gas is silicon tetrafluoride, which forms hydrofluorsilicic acid with water. Some silica is formed as a gel and care has to be taken to design a scrubbing system which will not easily block. From the conditioning tower the gases are taken to three intensive scrubbing towers in series. Liquor is recycled continuously in concentrated form and some is bled to a treatment tank where it is neutralized with an alkali to form sodium silico fluoride for the glass industry. There is no major liquid effluent discharge from this plant to the sea, the author being given to understand that only liquid from the final drowning tower goes to waste. In the writer's view the gas scrubbing system is adequate, but tests on the emission need to be carried out weekly by the company to show that proper control is being maintained. A standard of emission of not more than the SO_3 equivalent of hydrofluorsilicic acid of 250 mg/Nm^3 should be acceptable or there should be a scrubbing efficiency not less than 99 per cent (See Annex I, Ref. 3).

The company is also expanding its fertilizer business at the request of the Esso Fertilizer Co. to produce phosphoric acid and triple superphosphate. Briefly the process consists of the production of a solution of phosphoric acid by extracting phosphate rock with sulphuric acid and removing calcium sulphate by filtration. The phosphoric acid is then used to dissolve more phosphate rock to produce triple superphosphate. The process gases are not so noxious as the normal superphosphate, but they still need adequate scrubbing systems. In view of the complaints about the effect of the present liquid effluents on fish, it would be wise for Ministry officials to discuss with the company at an early stage their plans to dispose of the liquid effluent from this new process.

vi. Essa Fertilizer Co. Salaata

Visited: 10.11.66; Meeting with Mr. Kanaan, Plant Manager.

Briefly, liquid anhydrous ammonia is received by tanker every 3-4 weeks from Salonika and stored in a Horton sphere. This is used to make nitric acid, ammonium nitrate and ammonium sulphate and to ammoniate superphosphate. Superphosphate is received as a raw material from the adjoining Lebanese Chemical Co., and also imported are limestone and potash, the latter from Spain or Germany. These compounds are mixed in various proportions in a granulator to produce N-P-K compound fertilizers or "Calnitro" which is a mixture of ammonium nitrate and limestone. A flowsheet was provided by the management and it proved useful in understanding the complicated variety of products. The works began production in August 1966.

a. Nitric Acid. Ammonia vapour is burned with air over a catalyst and the resultant oxides of nitrogen are absorbed in water, all at a pressure of 9 atmospheres absolute. The plant was shut down for replacement of catalyst during the visit and there was no opportunity of seeing the intensity of the emission from the approximately 20 metres chimney. Production capacity is 78 tons/day as 100% nitric acid - actual make is 57% nitric acid. Laboratory chemists perform daily tests on the emission for oxides of nitrogen and oxygen and the records were examined. Results expressed as nitrogen dioxide were 0.1 to 0.2% - average 0.16%. This is equivalent to 1 600 p.p.m. and is satisfactory. Oxygen varied from 1% to 5%, average 3%, and this is normal. Oxides of nitrogen cannot be completely absorbed and some emission of the yellow gas has to be tolerated. There are only a few modern plants in the world fitted with catalytic tail gas reduction units which give an invisible final emission of about 200 p.p.m. as nitrogen dioxide. These are expensive and cannot reasonably be required for existing units. An emission below about 2 500 p.p.m. can be considered as acceptable.

b. Ammonium Nitrate. Unless there is a major breakdown with release of ammonia gas, these units are innocuous during normal operation. Ammonia vapour is absorbed in and reacts with nitric acid and there is no emission to air of offensive gases.

c. Ammonium Sulphate. Ammonia vapour is reacted with sulphuric acid in a completely enclosed crystallizer. Mother liquor is bled away and crystals of ammonium sulphate are separated in a centrifuge. The crystals are dried in an indirectly steam heated rotary dryer and the small amount of vapour is vented to air through a cyclone to remove ammonium sulphate dust. This is satisfactory.

d. Limestone. Limestone chippings are ground to a fine powder in a ball mill and the dusty air is vented through cyclones. This is satisfactory.

e. Granulation Plant. Raw materials are stored in four hoppers for nitrogen compounds (N), phosphorus compounds(P), potassium compounds (K) and limestone. The correct proportions are fed by weighing belt conveyors on to a main conveyor which delivers the mixture into the granulator. This consists of a rotating horizontal cylinder into which wet steam is blown, sometimes in admixture with ammonia vapour to ammoniate the superphosphate. Small wet granules of compound N-P-K fertilizer are produced which are then dried and cooled. The oil fired dryer and cooler are vented to air via cyclones and wet scrubbers. There is a special feature of the dryer which is worthy of mention. If the granules are over-heated, decomposition occurs and a dense mist is formed which can cause local annoyance and is very expensive to arrest. The secret in preventing mist formation is good control of the temperature in the dryer and not letting the flame from the heater "see" the product by offsetting the combustion chamber and dryer. In the installation seen, the oil fired combustion chamber is set at right-angles to the dryer. This is good practice.

The capacity of the granulation plant is 175 tons/day of "Calnitro" or 54 tons/day of various N-P-K complex compounds.

The whole works is under first-class management and equipment, instrumentation and control are excellent.

There are no recommendations to make concerning this works. All liquid discharges pass through limestone beds prior to running into the works drainage system and thence to the sea.

IV RESUME OF RECOMMENDATIONS AND STANDARDS

1. Recommendations

i. Cimenterie Nationale Ltd., Chekka

a. Instal an oxygen indicator on the waste gases from No.1 kiln.

e. For the two kilns it is preferable to have one common chimney of height not less than 110 metres. If two chimneys are used then theoretically each should be 110 metres, but in view of the high cost a reduction of each to 95 metres can be accepted with reluctance. If problems of foundations are put forward, a qualified, independent engineer should be asked for an opinion.

iii. Société Libanaise des Ciments Blancs, Chekka

a. Carry out a series of tests for dust concentration in waste gases when working at maximum capacity in order to assess whether better dust arrestment plant is needed or not.

b. Carry out a series of tests for hydrogen sulphide in the waste gases to assess the control of oxygen content.

iv. Société des Chaux et Plâtres du Liban, Chekka

a. Carry out a series of dust tests on the chimney gases to assess the performance of the dust arrestment plant at maximum capacity.

v. Lebanese Chemical Co., Salaata

a. Institute routine tests by the company for the total acidity of waste gases from the contact sulphuric acid and super-phosphate units and record the results for inspection. Weekly tests should suffice.

b. If not too late, the new contact acid plant should be designed with a chimney not less than 40 metres. Gas velocity in the chimney should be about 9 metres per second and the chimney top should be restricted by a truncated cone to give an efflux velocity of about 15 metres per second.

vi. Esso Fertilizer Co., Salaata

No recommendations.

2. Recommended Standards of Emission and Best Practicable Means

i. Cement Works

a. Dust content of waste gases from the kiln, which are mainly the raw materials and not cement, should be restricted to

450 mg/Nm^3 for new kilns on works with a total production up to 1 500 tons/day and to 225 mg/Nm^3 for new kilns on works with a total production in excess of 3 000 tons/day. Between 1 500 and 3 000 tons/day the maximum dust content should be on a sliding scale in proportion to the production rate.

b. Cement dust creates a greater nuisance than the dust in the waste gases from the kiln and operations such as clinker grinding and packing should be restricted to a cement dust content in the emission of 115 mg/m^3. The fitting of bag-filter units on these sections is normal practice and satisfactory emissions can easily be achieved if the bags are kept in good repair. Low level emissions from hoppers and conveyor changeover points should be prevented by suitable enclosure. Transfer of clinker to and from stock should be effected with a minimum of dust by the use of suitable grabs or conveyors which do not discharge their contents from high level.

c. Non-cement operations such as limestone crushing should be ventilated to air through dust arrestment plant designed for an outlet dust content not exceeding 450 mg/m^3.

d. Hydrogen sulphide should normally be absent from the waste gases from the kiln by suitable control of the oxygen content, but sometimes difficult materials have to be processed and in such circumstances a hydrogen sulphide content of 5 p.p.m. can be tolerated provided the chimney is tall enough to obtain good dispersion.

e. The chimney efflux velocity at maximum designed capacity should be not less than 15 metres/second.

f. A new chimney should not be less than 60 metres for a production capacity up to 60 tons/hour. Above this production the chimney height will depend on rate of production according to the graph drawn for the following table.

Production Rate Tons/hour	Chimney Height - metres		
	Wet Process	Semi-dry Process	Dry Process
30	60	60	60
60	86	79	73
90	104	94	85
120	118	107	96
240	151	140	126

When a new chimney is to be erected at a works where production to other chimneys already exists, the new chimney height must be increased to allow for existing pollution. This is an exercise which is difficult to describe in a report such as this and an opinion should be sought from the Chief Alkali Inspector, Ministry of Housing and Local Government, Whitehall, London, S.W.1., England on individual cases. Nomograms for this calculation are to be printed and a copy will be sent to the Ministry of Health in Beirut when available.

g. Existing works may not be able to meet the standards mentioned in paragraphs a. to f. above and some alleviation is necessary in order to avoid financial hardship. It is sometimes technically difficult to interpose modern arrestment plant on existing works and hard bargaining may be needed to arrive at a satisfactory compromise. In the absence of justified complaint it is suggested that the dust burden in waste gases from the kilns may be tolerated if it is not more than 1 000 mg/Nm^3, but schemes for expansion of production should include plans to reduce the emission from existing kilns to not more than 450 mg/m^3. Existing chimney heights may be tolerated if an assessment shows that no undue hardship is being experienced because of sub-standard dispersion, and hydrogen sulphide emissions are well under control.

ii. Lime Works. The target should be to reduce all dust emissions to not more than 450 mg/Nm^3.

iii. Plaster Works. The target should be to reduce all dust emissions to not more than 450 mg/Nm^3.

iv. Sulphuric Acid Works

a. The emission should be substantially free from persistent acid mist. It is not possible to quote a standard because the mist particle size and thus visibility will vary from plant to plant. A visual assessment will soon show whether a nuisance is created.

b. The total acidity of the emission should not exceed 2% of the sulphur burnt.

c. The chimney should be designed for a velocity not exceeding 9 metres/second so as not to entrain acid from the inner surface. The top of the chimney should be restricted in the form of a truncated cone to give an efflux velocity of 15 metres/second, so as to avoid downwash.

d. The height of discharge will depend on the production capacity according to the following table.

Production Tons/day	Chimney Height Metres
100*	29
200	40
300	48
400	57
500	64
600	70
800	81
1 000	90

* Note that the minimum height of chimney is 35 metres.

e. Care should be taken in the design of the final absorber to ensure that there is no carryover of acid droplets. This can best be done by arranging for non-splash distribution of acid over the packing and for a layer of dry packing in the top of the vessel just before the gases leave the unit.

v. Nitric Acid Works

a. The total acidity of the waste gases should not exceed 2 500 p.p.m. expressed as nitrogen dioxide, i.e. 5 g/m^3.

b. The velocity of efflux should not be less than 15 metres/second.

c. The chimney height should be based on a graph drawn from the following table, the minimum height of chimney for any size of nitric acid plant being 35 metres.

Production Tons/day	Chimney Height Metres
100	40
200	57
300	70
400	80
500	89

vi. Fertilizer Works

Superphosphate Units. The total acidity of the emission after scrubbing shall be not more than 250 mg/Nm^3, expressed as the sulphur trioxide equivalent of hydrofluorsilicic acid or absorption efficiency should be not less than 99 per cent.

Granulation Units. The emission from the dryer and cooler should pass through a cyclone and wet scrubber and the final emission should be at a height not less than 35 metres.

Phosphoric Acid and Triplesuperphosphate Units. The emissions from the reaction vessels should pass through a water scrubber before being released to air at a height of not less than 3 metres above surrounding buildings.

vii. General

a. Non-toxic dust emissions should not exceed 450 mg/m^3 unless the size of the unit is such as to require something more stringent.

b. Chimney Heights for combustion processes are usually based on sulphur dioxide emissions and the Memorandum of Chimney Heights issued by the British Ministry of Housing and Local Government is a good guide. (See Annex I, Ref. 4).

c. At the International Clean Air Congress in London in October 1966, Dr. E.A.J. Mahler presented a paper entitled "Standards of Emission under the Alkali Act". It is suggested that this paper could form a sound basis for standards of emission in the Lebanon. A copy will be sent to the Ministry of Health, Beirut, when available. (See Annex I, Ref. 3).

ANNEX I

REFERENCES

Ref. 1

British Standard 3405: "Simplified methods for Measurement of Grit and Dust Emission from Chimneys". A detailed description of the B.C.U.R.A. method is given in "Measurement of Solids in Flue Gases" by P.G.W. Hawksley, S. Badzioch and J.H. Blackett, published by the British Coal Utilization Research Association, Randalls' Road, Leatherhead, Surrey, England in 1961. See particularly Part One, pages 14 to 26. The apparatus can be obtained from Airflow Developments Ltd., Lancaster Road, High Wycombe, Buckinghamshire, England.

Ref. 2

"Methods for the Detection of Toxic Substances in Air". No. 1 Hydrogen Sulphide, 1958. Obtainable from Her Majesty's Stationery Office, 49 High Holborn, London, W.C.1., England. Price 4s.6d. plus postage. The hand pump tp be used for this test is obtainable from Baird and Tatlock (London) Ltd., Freshwater Road, Chadwell Heath, Essex, England.

Ref. 3

International Clean Air Congress, London, 4-7 October, 1966. Proceedings: Part I, p. 73-76 "Standards of Emission under the Alkali Act" by E.A.J. Mahler. Published by the National Society for Clean Air, Field House, Breams Buildings, London, E.C.4, England.

Ref. 4

Clean Air Act 1956. "Memorandum on Chimney Heights", Obtainable from Her Majesty's Stationery Office, 49 High Holborn, London, W.C.1, England, under S.O. Code No. 75-115.