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AIR QUALITY STANDARDS FOR THE CHEMICAL INDUSTRY

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SUMMARY:
The needs for standards to control air pollution are analysed. International trends in the development of more stringent emission standards and air quality criteria to combat the growth in air pollution are briefly reviewed, with particular reference to the chemical industry. The current legislation in South Africa and its application to chemical processes is considered in the light of increasing environmental awareness and the needs of our developing country. It is concluded that a process of continuous improvement to limit total emissions is necessary both to control pollution and conserve resources.
Air quality objectives to achieve this aim are proposed. The challenge is to meet them without increasing costs by developing appropriate clean technology.

INTRODUCTION

In order to provide a base for the control and abatement of gaseous emissions, chemical factories require a standard of acceptable ambient air quality. A study was carried out recently to determine air quality criteria for individual airborne pollutants common to many AECI factories. These criteria are based on an examination of overseas and local guidelines, legislation and standards relating to air quality.

THE NEED FOR AIR QUALITY STANDARDS

Gaseous emissions discharged to the atmosphere from chemical factories are dispersed by diffusion and mixing and can also be degraded in the atmosphere by physical, chemical and biological processes. When the inputs to the atmosphere exceeds the removal processes then a build-up of pollutants occurs to such a degree that their concentration may become sufficient to cause adverse effects upon man and his environment.

AECI's goal is to ensure that the quality of the air adjoining its factories is such that:

1. The health of the community will not be affected adversely.
2. The concentration of pollutants will not give rise to irritation effects, odour perception or cause annoyance.
3. Damage to vegetation and amenities will not occur.
4. Visibility will not be reduced significantly.

A qualitative measure of the success of achieving this goal will be minimal reaction from the community as a result of AECI's operations; ideally "zero complaints".

A quantitative measure will be the comparison of actual concentrations against those considered to be acceptable air quality criteria. Knowledge of these criteria is essential if one is to know whether the quality of air is good, adequate or unacceptable.

There has been a tremendous growth of industry in South Africa over the past 40 years to meet the needs of a rapidly growing and urbanising population, including increasing demands for a higher standard of living from all communities. Because of these changes the levels of pollution have tended to increase from industry, power generation, transport and domestic sources and have become concentrated in the vicinity of urban/industrial areas.

AECI's practice has been to design chemical processes to achieve emission standards, for individual pollutants from vents and stacks, which would not give rise to unacceptable ambient air quality. It is now no longer possible to consider single sources and emissions in isolation and their combined impact on the overal situation must be considered.

INTERNATIONAL AIR QUALITY CRITERIA AND STANDARDS

Over the past two decades due to the concern with increasing air pollution, particularly in North America and Western Europe, air quality guidelines have been researched and published. Legislation incorporating both emission and ambient air quality standards has been introduced by many countries. In general, the air quality standards relate only to the most common pollutants i.e. particulates, sulphur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), hydrocarbons, ozone (O_3) and lead. The high growth in burning of fossil fuels for energy generation and emissions from motor vehicles have led to these particular pollutants receiving close attention due to their potential adverse effects, including the formation of acid rain and photochemical smog. Table 2 compares the air quality standards for sulphur dioxide, nitrogen oxides and particulates for 8 countries including South africa.

In order to meet these air quality standards, emission reduction programmes for vehicles and power stations have been instituted in Europe and other countries. Chemical pollutants are also being restricted by tighter emission concentration standards or limits on total mass emissions.

Most of the standards relating to chemicals are emission-based, either by concentration or mass. However the World Health Organisation publication "Air Quality Guidelines for Europe" (1987) deals with 28 hazardous pollutants of which several are of relevance to AECI operations. These and other EEC guides are summarised in Tables 4 & 5. It is noteworthy that considerable protection (or safety) factors are built into the guidelines.

When using air quality criteria to evaluate risk, both concentration and exposure time have to be considered. Vegetation, for example, may suffer varying degrees of acute injury depending on pollutant concentration and duration of exposure. Vegetation may also suffer chronic injury from prolonged exposure to concentrations below the threshold for acute injury. The influence of air pollution on human beings has a similar dose-effect relationship.

Another valuable source of air quality criteria are the threshold limit values (TLV) issued annually by the American Conference of Governmental Industrial Hygienists (ACGIH) for a sizeable number of the substances encountered by workers in industry. The limits represent the time-weighted average concentrations to which nearly all workers may be repeatedly exposed for a normal 8-hour day and 40-h work week without adverse effect on their health.

The values must be regarded as useful guides rather than clearly-defined boundaries between safe and unsafe conditions.

TLVs are for use in the factory working environment, whereas ambient air quality criteria for the general population must protect the public including children, the elderly and the sick from exposure throughout their lifetime.

SOUTH AFRICAN LEGISLATION AND AIR QUALITY CRITERIA

The Atmospheric Pollution Prevention Act of 1965 is applied to industry in terms of 69 "scheduled processes". The Act is based on the "best practicable means" approach used until recently by the United Kingdom. No emission or ambient air quality standards are laid down in the Act, but unpublished guidelines which are regularly updated are used by the air pollution control authorities to negotiate emission standards for new or expanded plant.

The current ambient air quality criteria for the most common pollutants are given in Table 6. These guidance values are similar to the equivalent overseas standards. Where criteria are not available for a particular substance then the authorities recommend using a general guide of TLV/50 for 24 hour exposure of the community and TLV/100 if the airborne pollutant is carcinogenic or a cumulative poison. This rule of thumb tends to be more conservative when the values are compared to published standards and criteria.

In the past there has been considerable success in reducing dust emissions from major industries by implementing stricter standards. The main issues at present are concern about the build-up of SO_2 emissions leading to acid rain and the rising level of pollutants in the main industrial/urban areas. The national monitoring programme indicates that in specific locations concentrations of certain pollutants have increased to levels where pre-emptive action is being taken to reduce emissions before air quality becomes unacceptable.

DISCUSSION AND CONCLUSIONS

Ambient air quality criteria are well-established overseas and in South Africa for the most common pollutants, but there is relatively little information for other chemicals processed by AECI. However in the absence of information the use of TLV/50 (or TLV/100 as appropriate) for chemicals would appear to be acceptable as being somewhat more conservative when compared to published criteria. Protection (safety) factors are already built in to the latter. It is important to note the reduction in exposure limits with longer averaging periods.

Most published information relates to human health effects with limited data on effects on vegetation. In several instances, notably hydrogen sulphide (H_2S), odour threshold limits are considerably below the health criteria.

Another deficiency is the lack of data on the combined effects of pollutants with the exception of the relation between particulates and SO_2. As further research is carried out it is probable that air quality criteria will become more stringent in the future when more substances are evauated and combined effects assessed.

The gaps in current knowledge should not preclude efforts to set priorities for the reduction of pollutant sources. Such prioritisation is necessary if limited financial and manpower resources are to be used to achieve maximum air quality benefit.

STRATEGY FOR AIR QUALITY MANAGEMENT

AECI recognises its responsibilities in managing air pollution and wishes to achieve the previusly-stated goal of maintaining acceptable air quality in the vicinity of its factories. Ideally the overall aim is one of continuous improvement to reduce emissions progressively at each factory or, when new plant is installed, not to increase emissions above the current level.

The strategy developed to meet this goal is as follows:

1. Avoid or minimise air pollution at the process design stage of all projects.

2. Establish and maintain at each factory an inventory of gaseous emission sources and mass emission rates.

3. Use the mass emission rates to predict ground level concentrations by computation using dispersion models and compare these values with the available ambient are quality criteria.

4. Effect ambient air monitoring where appropriate to confirm actual concentrations.

5. Include in each factory environmental improvement plan schemes to reduce emissions with priority dependent on performance with respect to the air quality criteria and other factors.

6. Keep up-to-date with developments overseas and in South Africa relating to air quality criteria and measures introduced to protect air quality.

Elements of this strategy are already in place. The challenge is to meet the goal without significantly increasing costs by managing resources and utilising appropriate technology. In the case of new facilities, clean low-energy processes have already become available (or are being developed overseas) which have the advantage of both controlling pollution and conserving resources.

REFERENCES

1. 'Clean Air Around the World', International Union of Air Pollution Prevention Association, 1988.

2. 'Air Quality Guidelines for Europe', World Health Organisation, 1987.

3. 'Threshold Limit Values and Biological Exposure Indices for 1988-89' American Conference of Government and Industrial Hygienists.

4. Personal communication on Air Quality Standards, R J Perriman, ICI Brixham Laboratory, Sept 1989.

5. 'Allowable Concentration for the more common Pollutants: South African Limits', Department of Health, Air Pollution Control Directorate.

Table 1

SUBSTANCE	TLV		TLV/50 or TLV/100		ODOUR/IRRITATION* THRESHOLD		VEGETATION ** DAMAGE		
	ppm	mg/m3	ppm	mg/m3	ppm	mg/m3	ppm	mg/m3	time
AMMONIA	25	18	0,5	0,36	5,2		250-1000 40 16,6		4mins 1 hr 4 hr
CHLORINE	0,5	1,5	0,01	0,03	0,31		1,5 0,56		0,5hr 3 hr
HYDROGEN CHLORIDE	5	7	0,1	0,14	0,77		10		few hrs
HYDROGEN FLUORIDE	3	2,5	0,06	0,05	0,042		1 1-50ppb		1 hr sev hrs
HYDROGEN CYANIDE	10	10	0,2	0,2	0,58		20-40		5 hr
HYDROGEN SULPHIDE	10	14	0,2	0,28	0,008				
MERCURY (ALL FORMS)		0,05		0,0005	-			-	
NITROGEN DIOXIDE	3	6	0,06	0,12	0,39		25		few hrs
SULPHUR DIOXIDE	2	5	0,04	0,1	1,1		0,5 0,15 0,01	1,30 0,37 0,03	4 hr 24 hr year
VINYL CHLORIDE (CARCINOGEN)	5	10	(0,1)	(0,2)					

* Air odour thresholds relate to the average person. A sensitive person may be able to detect lower concentrations e.g. SO2 - 0,7ppm, NH3 - 0,7ppm.

** Concentration which could give rise to acute or chronic effects on vegetation.

Toxicity to vegetation ranking is chlorine > sulphur dioxide > ammonia > hydrogen cyanide > hydrogen sulphide
Susceptability of different plants to injury varies and the values given are only an indication.

Table 2

NATIONAL AMBIENT AIR QUALITY STANDARDS / CRITERIA (HUMAN HEALTH)

COUNTRY	SULPHUR DIOXIDE			NITROGEN DIOXIDE			PARTICULATE MATTER	
	µg/m3	ppm/vv	averaging	µg/m3	ppm/vv	averaging	µg/m3	averaging
USA*	80 345	0,03 0,14	year 24 hr	100	0,05	year	50 150	year 24 hr
AUSTRALIA**	60	0,02	year	320	0,16	year	90	year
TASMANIA	50 160 450		year 24 hr 1 hr	120 310	0,06 0,15	24 hr 1 hr		
CANADA*	60 300 900	0,02 0,11 0,34	year 24 hr 1 hr	100 200 400	0,05 0,1 0,2	year 24 hr 1 hr	70 120	year 24 hr
FINLAND	40 200 500		year 24 hr 1 hr	150 300		24 hr 1 hr	60 150	year 24 hr
JAPAN	120 300	0,04 0,1	24 hr 1 hr	120	0,06	24 hr	100 200	24 hr 1 hr
SOUTH AFRICA**	90 150 300 900 1800	0,03 0,05 0,10 0,3 0,6	year month 24 hr 1 hr instant peak	100 160 200 400 700	0,05 0,08 0,1 0,2 0,5	year month 24 hr 1 hr instant peak	50 350	year 24 hr
NETHERLANDS	500 830		24 hr 1 hr	175		1 hr	150	24 hr
ITALY							150	year
FEDERAL REPUBLIC OF GERMANY	140 400		Long term Short term	80 300		Long term Short term	150 300	Long term Short term

* Conditions of 25°c and 101,3 KPa used as the basis for conversion from µg/m³ to ppm.

** Conditions of 0°c and 101,3 KPa used as the basis for conversion from mg³ to ppm.
averaging times/year arithmetic mean of daily average concentration for one year.
averaging times/24 h arithmetic mean of hourly average concentration for 24hr.

Table 3

USSR - MAXIMUM PERMISSIBLE CONCENTRATIONS

SUBSTANCE	Max Permissible Concentration μg/m³	
	Max on one occasion	Average 24h
Nitrogen Dioxide	85	85
Hydrogen Sulphide	8	8
Sulphur Dioxide	500	50
Hydrogen Cyanide		10
Hydrogen Chloride	200	200
Mercury	-	0,3
Chlorine	100	30
Fluorine Compounds (as F)	20	5
Ammonia	200	200

These are more stringent than other foreign standards and the extent of compliance is not known.

Table 4

AIR QUALITY STANDARDS AND CRITERIA (ICI reference 9)

POLLUTANT	STANDARD/GUIDELINE
Sulphur dioxide (Ref 1)	80 – 120 $\mu g/m^3$ annual median of daily values 250 – 350 $\mu g/m^3$ 98 percentile of daily values over 1 year 40 – 60) as above – long term guidelines 100 – 150)
Nitrogen dioxide (Ref 2)	200 $\mu g/m^3$ percentile of hourly values over 1 year
Hydrogen chloride (Ref 3)	100 $\mu g/m^3$ daily mean 200 $\mu g/m^3$ max. hourly value
Hydrogen sulphide (Ref 4) (Ref 5)	5 $\mu g/m^3$ daily mean 10 $\mu g/m^3$ max. hourly value 7 $\mu g/m^3$ max. 30 minute mean
Chlorine (Ref 3)	100 $\mu g/m^3$ daily mean 300 $\mu g/m^3$ max. hourly value
1,2-dichloroethane (Ref 5)	700 $\mu g/m^3$ daily mean
Dichloromethane (Ref 5)	3000 $\mu g/m^3$ daily mean
Tetrachloroethylene (Ref 5)	5000 $\mu g/m^3$ daily mean 8000 $\mu g/m^3$ max. 30 minute mean
Trichloethylene (Ref 5)	1000 $\mu g/m^3$ daily mean
Vinyl chloride	No safe level. Lifetime risk exposure to 1 $\mu g/m^3$ is estimated to be 1 x 10^{-6}
Mecury	1 $\mu g/m^3$ annual average for indoor a pollution
Suspended particulates	80 $\mu g/m^3$ annual median of daily values

1. EEC Directive 80/779/EEC
2. EEC Directive 85/580/EEC
3. Technical Instructions for maintaining purity (T A Luft), West Germany 1974
4. Air Purity Regulations, West Germany, 1974
5. Air Quality Guidelines for Europe, WHO 1987