STAATSOLIE

MAATSCHAPPIJ SURINAME N.V.
state oil company suriname n.v.

Environmental Study

Phase I

Suriname Refinery Project

Tout Lui Faut

Lummus Crest B.V.

COMBUSTION ENGINEERING

ENVIRONMENTAL STUDY

PHASE I

SURINAME REFINERY PROJECT

TOUT LUI FAUT

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1. INTRODUCTION

One of the most important considerations during the realization of a modern plant project is the impact of the plant on the environment. In the past the impact of human activities has been such that air, water and ground pollution have become serious enough that national and international regulations have been set up to protect human beings, animals, plants as well as total ecosystems against unwanted effects. These regulations have been set up by local authorities, national governments and international organizations such as EC or World Bank.

2 As there are currently no petroleum refining environmental design regulations in Suriname, Lummus Crest B.V. was requested by "Staatsolie" to establish suitable environmental design recommendations. A survey is made of the different standards for allowable environmental immission levels dealing directly with health or environmental effects and the emission levels, which are of direct concern for petroleum refining activities.

National and international codes and standards generally cover the minimum requirements to meet the following principles:

- Stand still, which means no further deterioration of the environment.
- Use of technologies, which are available and economically feasible.

Since so-called "end of pipeline" treatment methods generally mean extra costs and some governmental regulations imply taxes raised on basis of polluting materials, the following principles of environmental control are also met:

- Minimizing the quantities of produced waste by changes in the process instead of treating afterwards.
- Prevention of unnecessary pollution.

Most regulations are dealing with gaseous and water effluents, since these have a direct and visible effect on the environment.

The survey included regulations of the following countries/ organizations:

- World Bank.
- USA (EPA).
- EC.
- Germany (TA Luft).
- The Netherlands.

These regulations are often related to each other, althoug not always given in the same units.

For comparison, the environmental regulations of two other countries, India and Saudi Arabia, working on their basic industrial development have been added.

2. GASEOUS EFFLUENT

2.1 GENERAL

The main sources are the following:

a. Flue gas due to combustion of fossil fuels. Fossil fuels include coal, oil and its derivatives and natural gas. Main combustion products contributing to air pollution are sulfur oxides, nitric oxide, carbon monoxide and particles, the first two responsible for the formation of acid rain. The emission of the last two products is limited primarily to protect human health.

b. Flare gas originating from emergency venting. The flare system should be used for safety only and must never be used as an incinerator. Since flaring often results in incomplete combustion, flare gases may also contain apart from the combustion products mentioned under a., unburned hydrocarbons or H_2S.

2 c. Venting, either controlled or diffuse. Although controlled venting of noxious products should be avoided as much as possible, they still may occur. Uncontrolled or diffuse venting originates from the following sources:

- Leaking flanges, valves and safety valves.
- Breathing of storage tanks and vapor displacement during filling.
- Vapor losses during loading and unloading of products.

A limited amount of particulates emissions arises from furnaces and steam boiler firing plants, from waste incineration, from catalytic cracking working in accordance with the fluidized bed system and during the treatment of coke.

2.2 SURVEY OF STANDARDS OF IMMISSION LEVELS

Appendix 1 shows the maximum immision levels provided by various organizations of the main polluting substances in the atmosphere.

Sulfur dioxide is considered to be dangerous to men. It also oxidizes in the atmosphere forming sulfur trioxide, which combines with moisture to form sulfuric acid. High levels of sulfate concentrations will aggravate asthma and long and heart disease. It also contributes to the formation of acid rain and can affect plants and trees. Low levels of sulfur dioxide in combination with ozone and nitrogen oxide can severely damage the vegetation.

Immission levels are standards which apply to the ambient air quality. US standards, EC, German and Dutch standards give two levels which are to be adhered to. The first (the highest) level represents air quality which has to be maintained for human health reasons, while the second level is to be strived after for environmental reasons. The levels are given as concentrations in the ambient air in ug/m^3. The absolute figures represent averages of the measured values over a year and a day respectively.

In The Netherlands, some values are given in 98 percentile, which means 98 percent of the measured 24 hours average values is lower than the indicated value. This means that the yearly average will be lower, while the maximum 24-hour average will be higher than this value. For example for SO_2 the 98 percentile is 250 $\mu g/m^3$, the maximum 24-hour average is 500 $\mu g/m^3$. Compared with EC values, this corresponds to a yearly average of 140 $\mu g/m^3$.

Nitrogen oxide is present in the atmosphere from natural as well as from men-made sources. Nitrogen oxides produced by men originate from transportation means and stationery combustion sources, proportions of which are variable for different countries.
However, generally 50% originates from industrial combustion. Nitrogen oxides take part in the reactions which take place in the atmosphere. Appendix 2 shows the various reactions which are occurring. Also unburned hydrocarbons can react with nitrogen oxides resulting in photochemical oxidants. Ozone is another photochemical oxidant. Highly oxidized nitrates form components in so-called photochemical smog, which irritates the eyes, longs and aggravates respiratory diseases. Nitrogen oxides are also toxic to vegetation. They can be further oxidized to nitrogen pentoxides which combine with moisture to from nitric acid, thus contributing to the formation of acid rain.

Immission standards for carbon monoxide are primarily meant to protect human health. CO reacts with hemoglobine (oxygen carrier in blood) causing lack of oxygen and possibly asphyxiation. As smokers are exposed to relatively high concentration of CO, this air quality standard mainly applies to nonsmokers.
Particles means all inhalable particulates present in air. However, the EC standards apply only to dark colored particles, due to the agreed analyzing method as pointed out by the OESO, which is based on the concentration of black particles in the ambient air (black smoke). Particles suspended in the atmosphere have sizes between 0.1 µm and 500 µm. However, particles of 0.2 µm and smaller are exhaled as readily as they are inhaled. Particulates add up to smog formation and can produce allergic reactions, respiratory effects and skin and eye irritation.

For other materials no immission values are given, which have a legal status, except for some heavy metals and chlorine compounds in the German standard and lead in the EC and Dutch standards.
In The Netherlands preliminary limit values have been set up for several compounds based on their MAC values and a certain safety factor. These compounds have been categorized after their toxicity and persistence for the environment. The MAC value represents the maximum allowable concentration to which a normal healthy human being is allowed to be exposed during 8 hours a day and not longer than 40 hours a week.

For compounds, for which no ambient air value has been established yet, the following limits are used:

- Category 1 : 0.001 x MAC value.
- Category 2 : 0.01 x MAC value.
- Categories 3 and 4 : 0.03 x MAC value.

These values are used, unless the threshold value for odor is lower than the MAC value. In that case the immission limit is 0.3 x this value.

- Category 1 : Toxic and persistent for the environment.
- Category 2 : Toxic, but not persistent.
- Category 3 : Hardly toxic nor persistent.
- Category 4 : Other.

A list of compounds is given in appendix 3, indicating category, MAC value, odor threshold values and immission limits.

2.3 SURVEY OF STANDARDS OF EMISSION LEVELS

Appendix 4 shows emission standards provided by various organizations. These limitations are generally applicable for source emissions and are based on:

- Values, which can be achieved by the available technology and which are necessary and economically feasible.
- Values, leading to the realization of the immission values mentioned in the previous paragraph.

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The measures taken to limit the emissions are to be based on a limitation of the concentration values in the discharged stream on one side, as well as on a limitation of the total mass flow leaving an installation on the other side. The emission values indicate the allowable concentrations of the contaminant at the point of discharge, before any mixing takes place with air.

Emission of sulfur dioxide is directly depending on the sulfur content of the fuel and therefore mainly applies to fossil fuel burning facilities like coal and oil and H_2S containing fuel gas.

Provisions to decrease SO_2 emission may consist of flue gas cleaning, mainly applied to coal and oil combustion or fuel desulfurization (oil and gas) by conversion to H_2S by catalytic hydrogenation and subsequent removal of H_2S.

Emission of nitrogen oxides by combustion processes is due to oxidation of atmospheric nitrogen in the combustion air ("thermal NO_x") or conversion of nitrogen present in the fuel ("fuel NO_x").

Reduction of NO_x in flue gases can be achieved by changes in the operating conditions like reduced excess air or changes in the fuel properties like reduction of "N" content, which is not practical or use of low caloric gases thus reducing the flame temperature.

However, more common reduction techniques consist of the use of low NO_x burners, air staged or fuel staged burners. In these burners air or fuel is added in two or three stages, such that formed NO_x is reduced to N_2 in a fuel rich environment. A third type is a burner with internal circulation of flue gases. Other techniques, only applicable to new furnaces, reduce the emission of NO_x by changes in the fire zone. Flame temperatures can be lowered by increasing the distances between the burners. Air staging in the firing zone can be achieved by injecting combustion air outside the combustion zone. Fuel staging in the firing zone is another modern technique, at which combustion takes place in three consecutive firing zones. A third technique recycles the flue gas externally by means of an external flue gas blower.

The emission of particulates from boilers and process heaters is largely a function of the fuel used. In case of coal burning, it highly depends on the ash content, which will appear as fly ash in the flue gases. When burning oil, smoke can be created due to improper combustion.

In this case smoke formation can be suppressed by a higher excess air quantity, although this is in contradiction with the requirements for low NO_x. Particulates removal can be achieved by means of cyclones or electrostatic precipitators.

These are the main substances responsible for air pollution, for which emission standards are provided. Some standards (EPA, Saudian standards) prescribe the use of floating roofs on storage tanks for hydrocarbons having a vapor pressure at ambient temperature of more than 0.1 bara or a vapor recovery system for hydrocarbons with a vapor pressure higher than 0.75 bara.

The German standards (TA Luft) have divided a number of organic compounds into three categories. For each category the emission is limited to values shown below:

Category No.	Mass Flow	Concentration
I	0.1 kg/h	20 mg/m^3
II	2 kg/h	100 mg/m^3
III	3 kg/h	150 mg/m^3

Organic compounds, for which these values apply are listed in appendix 5.

The same approach has been followed for carcinogenic compounds, solid inorganic compounds and inorganic vapors, making the TA Luft a very complete standard for emissions.

2.4 RECOMMENDATIONS

In general, standards as provided by the World Bank are recommended, unless there is no standard given or the World Bank standard is not comparable to the others or not realistic in LCV's opinion.

As far as the immission values for the common flue gas pollutants are concerned, World Bank standards are recommended to be adopted. For CO, the German standard is recommended. The values for SO_2 and particulates are given as yearly and daily averages not to be exceeded. NO_x and CO are only provided as yearly averages. Only Dutch standards provide daily, respectively 8 hours average, but then as a 98 percentile, which is not directly comparable.
For other compounds, the approach based on MAC values is recommended, as applied in The Netherlands and described in paragraph 2.2.

The emission standards, set by the World Bank for NO_x and particulates fall in the same range as the other standards and are therefore recommended. The SO_2 standard, however, is extremely high and not recommended for fuel oil firing. The World Bank standard is considered unrealistic for refinery type plants. Appendix 6 shows emission factors of refineries between 1975 and 1981 in g/GJ. This table shows a significant decrease in SO_2 emission, the values in the last years corresponding to the Saudian standard of 1 g/MJ. This value is therefore recommended as a guideline.

3. WATER EFFLUENT

3.1 GENERAL

The main sources of industrial waste water are:

a. Process Waste Water

In a refinery the principal source of process waste water consists of water extracted during the desalting of the crude. This water contains mainly salts and hydrocarbons. Other sources are settled water in the crude tanks, sour water from stripping processes containing dissolved gasses as H_2S and NH_3 and ballast water from ships.

b. Rainwater

This water is generally divided in clean water and oily water, depending on the area where it is collected. Water from bunded tank areas can be clean or oil contaminated. The same applies to firewater spilled during a fire.

c. Cooling Water

In case of once through cooling water system, the main pollutant is temperature increase of the receiving water. Also, in case of leakage, this water may be contaminated with oil. Finally, when chlorination is applied to prevent algae growth, the water can contain chlorine. In case of closed cooling water system, the discharged quantity is greatly reduced, but may contain hazardous chemicals used for water conditioning.

d. Boiler Blowdown

This is only a small quantity with a relatively high temperature (after cooling). This effluent too may contain hazardous chemicals used for boiler feedwater conditioning.

e. Domestic Waste Water

Originating from offices, laboratory or wherever people are working. This water contains normal biodegradable pollutants as BOD and N-Kjehldahl.

3.2 SURVEY OF WATER QUALITY STANDARDS

Water quality standards are based either on the protection of the ecological environment or more specifically when it is used for human consumption. The EC has given guidelines for water quality standards to be set for water indicated as fish water or water to be used for drinking water after treatment. In The Netherlands these guidelines have been used to specify the water quality for the various destinations. Appendix 7 gives quality standards for water to be used for drinking water and appendix 8 for fish water as applied in The Netherlands. Although the designation fish water could also be considered as intended for human consumption, it also contains ecological elements. Wat qualities for the preparation of drinking water are divid in thee categories:

Category No.	Treatment
I	Simple treatment and disinfection.
II	Normal physical and chemical treatment and disinfection.
III	Extensive physical and chemical treatment, polishing and disinfection.

Each category contains two sets of standards, A and B. Figures under A are standards to be applied by the authorities responsible for the surface water quality, while figures under B are the limits for the potable water producer, i.e. when these limits are exceeded, intake of subject water is to be stopped.

Appendix 9 shows potable water quality standards issued EC. The table shows the main detectable substances. Dutc potable water standards are derived from these standards.

Effluent waters generally contain the following pollutants:

- Suspended solids make the water muddy, improper for swimming water and expensive for use as raw water for potable water.
- Floating substances like oil cause depletion of oxygen and consequently death of fish.
- Colloidal dissolved substances give an unpleasant yellow color to the water.

- Higher temperatures decrease the solubility of oxygen and decrease the oxygen concentration of the receiving water by an higher oxidation of organic matter.
- Inorganic salts which cannot be removed, make the water unsuitable for drinking or irrigation water.
- Biodegradable Organic matter (BOD) decreases the oxygen content of the water with the already mentioned consequences.
- Substances like heavy metals, pesticides herbicides, or radioactive materials are toxic to the aquatic organisms and human beings.
- Nitrates and phosphates cause excessive algae growth (eutrophication) which may lead to massive mortality and a sudden decrease in oxygen content.
- Biological pollution by viruses and bacteria causing diseases.

3.3 SURVEY OF WATER EFFLUENT LIMITATION

Liquid effluents will generally be at a higher temperature than the receiving water. Therefore, care must be taken to keep the temperature difference as small as possible to avoid harmful effects on aquatic plants and animals. According to the World Bank guideline, effluent temperature should not be more than 3°C higher than that of the receiving water. Where the receiving water temperatures are at 28°C or less, the effluent temperature may be maximum 5°C above that of the receiving water.

Appendix 10 shows water effluent limitations issued by various authorities. For comparison Dutch limitations for surface water quality has been added. Standards are given in various different units. US standards given absolute values per plant. World Bank and India provide values per 1,000 ton of feed, while India, Saudi Arabia and water quality figures provided by EC and The Netherlands, also give maximum concentrations of pollutants in the water. The effluent limitations are based on best available technologies economically feasible, or best conventional pollutant control technology.

These techniques applicable for liquid effluent disposal include in-plant measures and process changes, like reduced flows through greater recycle and reuse of waste waters, or on-site treatment facilities designed to reduce specific contaminants. These include sour water strippers, oil-water separators, flotation units and biological treatment units. If present, industrial effluent could be discharged into a municipal sewer system after pretreatment in accordance with the requirements of the municipal authorities.

3.4 RECOMMENDATIONS

For water quality standards Dutch standards for fish water are recommended for the surface water quality after disposal of treated effluent. Although these standards are meant to serve a specific purpose, water with this quality can be considered as healthy from an ecological point of view.

Potable water standard may vary between different countries. Although EC standards are somewhat more stringent than WHO standards, EC standards are recommended. This standard provides an extensive list of constituents, which may be present in the raw water used to prepare drinking water. These values are to be met, except for those which only influence taste or color, like TDS. Apart from hygienical liability of the drinking water and the absence of toxic substances, some materials influence public health in larger quantities, especially nitrates, nitrates, magnesium and barium. This also applies to fluoride, which in small quantities has a healthy effect on teeth, but in larger quantities causes mottling of tooth enamel and weakening of human bones.

For water effluent limitations the Indian standards are recommended. US standards give absolute values which are not applicable to small plants. The World Bank standards are rather high. Moreover, these standards are not very practical with regard to treatment methods. This also applies to the first set of Indian standards. Therefore, the concentration limits provided by the Indian standards are recommended as standards to be met after treatment of the water effluent. Also, they are comparable with the Saudian standard and the Dutch surface water quality standards. For all other compounds care must be taken that concentrations in the surface water are not exceeded.

4. SOLID EFFLUENT

Solid effluent from refineries consists mainly of process sludge and spent catalyst and sludge from oil/water separators and biological treating units. Solids contained in effluent water and flue gases are already dealt with in the respective chapters. Solid effluent can be continuous or intermittent. Continuous effluents are those resulting from continuous sludge disposal from waste water treating units, however, the produced quantity can vary.

Intermittent effluents result from cleaning of tanks, vessels and other process equipment during plant turnarounds, including removal of spent catalyst. Quantity and characteristics of intermittent waste depends on type of crude, type of processes and the degree of maintenance.

As for all effluents, but especially for solid waste, the most effective environmental control is to reduce the quantity. This can be achieved by better process control, change of process or use of catalyst with a longer lifetime. Quantity of sludge can be reduced by concentration.

Solid waste can contain a large variety of substances. Classification in accordance to their environmental effect is required to obtain a proper way of disposal. This classification should be based on toxicity, biodegradability, air polluting or groundwater polluting. Proper location and operation of disposal sites are one of the principal factors in handling solid waste, if landfill is used as the way to dispose off.

Sludge from biological plants can serve agricultural purposes if care is taken that no harmful substances are added. Chemical and organic waste can be destroyed by incineration. In all cases, standards for immission, emission as well as for water quality are applicable as described in the previous chapters. Especially for incinerators, emission and immission standards shall be observed, since toxic substances may be released through incineration. Sites used for landfill should be designed and operated to prevent or minimize water runoff. Unprotected waste piles are subject to leaking which may result in acidic or alkaline effluents percolating to streams or aquifers used for drinking water supply.

5. NOISE

Noise is described as undesired, unpleasant or even harmful sound. Noise is produced by vibrating parts of equipment, which directly generate pressure waves in the surrounding air or by turbulent gas streams around obstacles or by sudden changes in volume caused by heat, which can produce pressure waves.
The propagation of sound is by pressure waves traveling, generally through air, with the speed of sound.
In air the speed of sound is approximately 350 m/s.
Sound vibrations can also be transferred to the surrounding construction. This is the reason that noise from compressors, pumps and control valves, although they are the direct source, is mainly caused by the often much larger surface of the adjacent piping.

Noise is expressed in decibels (dB) and can be indicated by a sound power level or a sound pressure level. The sound power level in dB equals ten times the logarithm of the ratio of the sound power level in W to a reference level. The sound pressure level in dB equals twenty times the logarithm of the ratio of the sound pressure level in N/m^2 to a reference level. The sound pressure level of a noise source is not a fixed value. It is depending on the distance from the source and the directivity of the source. A noise source is identified by its sound power level. A sound pressure level can be attributed to a location with regard to the noise source.

The human ear has the capability to hear and recognize sounds of different frequencies. Normal sound consists of a spectrum of frequencies. The human ear is capable of hearing frequencies from 15 Hz to 16 kHz, depending on age. However, not every frequency is observed at the same level. An internationally agreed "A" correction compensates for these differences. Sound levels expressed in dB(A) therefore represent the level received by the human ear.

An indication of the sound pressure levels caused under various situations is given in appendix 11. Noise sources can be either continuous or intermittent. Intermittent sources are generally considered as more annoying, even if the level is lower, although this is also dependent on type of source.

Continuous sound pressure levels above 90 dB(A) have detrimental effects on human ear and human performance. In general, sound pressure levels of maximum 85 dB(A) are specified for in-plant noise, which means to locations where operators may be present. However, there is a tendency to lower this to 80 dB(A) but this difference often requires other measures than what can be reacted with silencers, enclosures and insulation.

Acceptable environmental noise levels are very dependent on the environment. In rural environments lower sound pressure levels are allowed than near cities. Sometimes it is specified that the noise contribution of a plant is not detectable at a certain location.
In The Netherlands a 24-hour value of 50 dB(A) is specified at the nearest houses, which corresponds to a sound pressure level at that location of 50 dB(A) during day time and 40 dB(A) at night. This "far field" noise level determines the maximum sound power level, which a total plant may radiate to the surroundings. However, ground and air attenuation effects can be subtracted.

For in-plant noise a maximum sound pressure level of 85 dB(A) is recommended. For environmental noise a maximum 24-hour sound pressure level of 50 dB(A) is recommended.

6. RECOMMENDED ENVIRONMENTAL DESIGN CRITERIA

Appendix 12 summarizes the recommended environmental criteria for immission, emission, water effluent limitations and noise limitations.

For immission values of other compounds than indicated the approach as given in paragraph 2.2 is recommended. For emission values of other compounds than indicated the method given in TA Luft (see paragraph 2.3) is recommended. For compounds not mentioned under water effluent limitations, care shall be taken that limits set for surface water, as given in paragraph 3.2 are not exceeded.

Emission values imposed to new complexes should be considered in concurrence with existing emissions and required immission values.

Although standards are based on available technologies, they may not always be applicable or economically feasible. This should be considered on a case-to-case basis and authorities could permit for temporary or permanent higher values, taking into account the total impact on the environment, including possible future extensions of the industrial area.

IMMISSION STANDARDS CONCENTRATION ($\mu g/m^3$)

Year/24 hrs	World Bank	USA	Germany	EC	Neth	India	Saudi Arabia	WHO
SO_2/SO_3 (health effects)	100/1000	80/365	140/-	140/-	-/500	120/-	85/400	60/150
SO_2/SO_3 (environmental effects)	100/500	60/260	50/-	60/150	-/100			
NO_x	100/-	100/-	80/-	-/-	-/120 (Note 1)	120/-	100/-	-/-
CO	-/-	10000	10000/-	-/-	6000 (Notes 1 and 2)	5000/-	10000 (Note 3)	-/11500
Particulates (health effects)	100/500	75/260	150/-	150/-	-/150	500/-	80/340	60/150
Particulates (environmental effects)					60/- (Note 1)	-/100		

Notes:
1. 98 percentiles.
2. 8-hour average.

REACTIONS IN AIR

Oxygen

O_2	+	energy	-->	O	+	O
O	+	O_2	-->	O_3		
O	+	O	-->	O_2		
O	+	O_3	-->	$2O_2$		
O_3	+	energy	-->	O_2	+	O

With Nitrogen Oxides

O_3	+	NO	-->	NO_2	+	O_2
O_3	+	NO_2	-->	NO_3	+	O_2
NO_3	+	NO	-->	$2NO_2$		
NO_3	+	NO_2	-->	N_2O_5		
N_2O_5	+	H_2O	-->	$2HNO_3$		
NO_2	+	energy	-->	NO	+	O

With Hydrocarbons (Butane)

C_4H_{10}	+	O	-->	$C_4H_9^{\cdot}$	+	$OH^{\cdot}$
C_4H_{10}	+	$OH^{\cdot}$	-->	$C_4H_9^{\cdot}$	+	H_2O
$C_4H_9^{\cdot}$	+	O_2	-->	$C_4H_9OO^{\cdot}$		
$C_4H_9OO^{\cdot}$	+	NO	-->	$C_4H_9O^{\cdot}$	+	NO_2
$C_4H_9O^{\cdot}$	+	O_2	-->	C_3H_7CHO	+	$HO_2^{\cdot}$
$HO_2^{\cdot}$	+	NO	-->	$OH^{\cdot}$	+	NO_2
C_3H_7CHO	+	$OH^{\cdot}$	-->	$C_3H_7C(=O)^{\cdot}$	+	H_2O
$C_3H_7C(=O)^{\cdot}$	+	O_2	-->	$C_3H_7C(=O)OO^{\cdot}$		
$C_3H_7C(=O)OO^{\cdot}$	+	NO_2	-->	$C_3H_7C(=O)OONO_2$ (peroxybutyrylnitraat)		

REACTIONS IN AIR (Cont'd)

Sulfur Dioxide

$2SO_2$	+	O_2 (+M)	-->	$2SO_3$
SO_3	+	H_2O	-->	H_2SO_4
$2NH_3$	+	H_2SO_4	-->	$(NH_4)_2SO_4$

Fluoro Hydrocarbons

$CFCl_3$	+	energy	-->	$CFCl_2$	+	Cl
Cl	+	O_3	-->	ClO	+	O_2
ClO	+	O	-->	Cl	+	O_2

	Categorie	MAC-waarde mg/m³	Reukgrenzen onder mg/m³	Reukgrenzen boven mg/m³	Schadelijkheidsgrenswaarde mg/m³
aceton	4	2400	1	1500	70
acetyleen	4		-		
acroleine	2	0,25	0,05	4	0,003
acrylnitril	1	9	-	-	-[1]
ammoniak	2	18	0,1	42	0,18
azijnzuur	2	25	0,25	6	0,25
azijnzuur anhydride	2	20	-	-	0,2
benzeen	1	30	3	420	0,005[1]
blauwzuur	2	11	(1)		0,11
butaan	4	1430			40
n-butanol	2	150	0,2	33	1,5
n-butylacetaat	2	710	0,03	35	0,2
chloor	2	3	0,06	14	0,03
chloroform	1	120	30	3700	0,12
cyclohexaan	2	1050	2	2700	10
cyclohexanon	2	200	0,02	0,2	0,03
1,2 dichloorethaan	1	200	17	1500	-[1]
dichloormethaan	1	700	4	1100	0,7
diethylether	2	1200	(1)		0,3
epichloorhydrine	1	4	-	-	0,004[1]
ethaan	4		-	-	
ethanol	4	1900	7	2600	30
ethylacetaat	2	1400	0,6	180	3
ethyleenoxyde	2	90	-	-	0,9
fenol	2	19	0,02	7	0,1
fluorwaterstof	1	2	-	-	0,006
formaldehyde	2	3	0,07	2	0,03
fosforwaterstof	2	0,4	0,1	7	0,004
fosgeen	2	0,4	0,5	4	0,004
furfurylalcohol	2	20	-	-	0,02
n-heptaan	2	1600	(93)		16
n-hexaan	2	360	-	-	3,6
hydrazine	1	0,13	-	-	0,001[1]

	Categorie	MAC-waarde mg/m³	Reukgrenzen onder mg/m³	Reukgrenzen boven mg/m³	Schadelijkheidsgrenswaarde mg/m³
isobutylacetaat	2	700	0,6	-	0,3
isopropylalcohol	2	980	8	1500	10
kooldioxyde	4	9000	-	-	270
koolmonoxyde	4	55	-	-	2
methaan	4	-	-	-	-
methanol	2	260	4	7800	2,6
methylacetaat	2	610	0,002	-	0,005
methylbromide	1	60	-	-	-[1]
methylbisfenylisocyanaat MDI	2	0,2	-	-	0,002
methylethylketon	2	590	0,7	250	5
methylformiaat	2	250	-	4	2,5
methylisobuthylketon	2	410	0,4	10	0,5
methylmetacrylaat	2	410	0,2	0,8	0,1
a-methylstyreen	2	480	0,04	-	0,03
monochloorbenzeen	1	350	-	-	0,35
naftaleen	2	50	0,004	50	0,01
ozon	2	0,2	0,015	0,5	0,002
n-pentaan	2	360	-	-	3,6
perchloorethyleen	2	240	19	320	2,4
n-propylacetaat	2	840	-	-	8,4
propyleenoxyde	2	240	-	-	2,4
pyridine	2	15	0,04	6	0,05
stikstofdioxyde	2	9	0,1	0,8	0,05 (stikstofdioxyde + stikstofmonoxyde)
stikstofmonoxyde	2	30	-	-	
styreenmonomeer	2	420	0,02	8	0,03
tolueen	2	375	0,08	170	1
tolueendiisocyanaat TDI	2	0,14	-	-	0,001
1,1,1-trichloorethaan	1	1080	-	-	1
1,1,2-trichloorethaan	2	45	-	-	0,045
trichloorethyleen	2	190	-	-	1,9
vinylchloride	1	± 0	-	-	-[1]
waterstof	4	-	-	-	-
xyleen	2	435	0,6	24	1
zoutzuur	2	7	0,2	7,5	0,07
zwaveldioxyde	2	13	0,9	21	0,04
zwavelkoolstof	2	60	0,05	1,3	0,05
zwavelwaterstof	2	15	0,0001	2	0,001
zwavelzuur	2	1	(1)		0,01

EMISSION STANDARDS

	World Bank	USA	Germany	Neth	Saudi Arabia	India
SO_2/SO_3	500 TPD	340 mg/MJ	1700 mg/m^3	2000 mg/m^3	1 g/MJ	0.25 kg/ton crude
	100 TPD (Note 1)	(Note 4)	(Note 2)	(Note 2)		2.5 kg/ton feed (Note 3)
NO_x	130 mg/MJ	129 mg/MJ	450 mg/m^3	450 mg/m^3	130 mg/MJ	-
Particulates	100 mg/m^3	43 mg/MJ	80 mg/m^3	50 mg/m^3	43 mg/MJ	-

Notes:

1. Tons per day: Lowest value for polluted areas.
2. For refineries, not for other combustion installations.
3. First figure for atmosphere and vacuum distillation units, second figure for catalytic crackers.
4. For refinery fuel gas combustion devices: No fuel gas which contains H_2S in excess of 230 mg/dry standard m^3.

Stof			Klasse
Acetaldehyd		C_2H_4O	I
Aceton		C_3H_6O	III
Acrolein	siehe 2-Propenal		
Acrylsaure		$C_3H_4O_2$	I
Acrylsaureethylester	siehe Ethylacrylat		
Acrylsauremethylester	siehe Methylacrylat		
Alkylalkohole			III
Alkylbleiverbindungen			I
Ameisensaure		CH_2O_2	I
Ameisensauremethylester	siehe Methylformiat		
Anilin		C_6H_7N	I
Benzylchlorid	siehe α-Chlortoluol		
Biphenyl		$C_{12}H_{10}$	I
2-Butanon		C_4H_8O	III
2-Butoxyethanol		$C_6H_{14}O_2$	II
Butylacetat		$C_6H_{12}O_2$	III
Butylglykol	siehe 2-Butoxyethanol		
Butyraldehyd		C_4H_8O	II
Chloracetaldehyd		C_2H_3ClO	I
Chlorbenzol		C_6H_5Cl	II
2-Chlor-1.3-Butadien		C_4H_5Cl	II
Chloressigsaure		$C_2H_3ClO_2$	I
Chlorethan		C_2H_5Cl	III
Chlormethan		CH_3Cl	I
Chloroform	siehe Trichlormethan		
2-Chloropren	siehe 2-Chlor-1.3-Butadien		
2-Chlorpropan		C_3H_7Cl	II
α-Chlortoluol		C_7H_7Cl	I
Cumol	siehe Isopropylbenzol		
Cyclohexanon		$C_6H_{10}O$	II
Diacetonalkohol	siehe 4-Hydroxy-4-methyl-2-pentanon		
Dibutylether		$C_8H_{18}O$	III
1.2-Dichlorbenzol		$C_6H_4Cl_2$	I
1.4-Dichlorbenzol		$C_6H_4Cl_2$	II
Dichlordifluormethan		CCl_2F_2	III
1.1-Dichlorethan		$C_2H_4Cl_2$	II
1.2-Dichlorethan		$C_2H_4Cl_2$	I
1.1-Dichlorethylen		$C_2H_2Cl_2$	I
1.2-Dichlorethylen		$C_2H_2Cl_2$	III
Dichlormethan		CH_2Cl_2	III
Dichlorphenole		$C_6H_4Cl_2O$	I
Diethanolamin	siehe 2.2'-Iminodiethanol		
Diethylamin		$C_4H_{11}N$	I
Diethylether		$C_4H_{10}O$	III
Di-(2-ethylhexyl)-phthalat		$C_{24}H_{38}O_4$	II
Diisobutylketon	siehe 2.6-Dimethylheptan-4-on		
Diisopropylether		$C_6H_{14}O$	III
Dimethylamin		C_2H_7N	I
Dimethylether		C_2H_6O	III
N.N-Dimethylformamid		C_3H_7NO	II
2.6-Dimethylheptan-4-on		$C_9H_{14}O$	II
Dioctylphthalat	siehe Di-(2-ethylhexyl)-phthalat		
1.4-Dioxan		$C_4H_8O_2$	I
Diphenyl	siehe Biphenyl		
Essigester	siehe Ethylacetat		
Essigsaure		$C_2H_4O_2$	II
Essigsaurebutylester	siehe Butylacetat		
Essigsaureethylester	siehe Ethylacetat		
Essigsäuremethylester	siehe Methylacetat		
Essigsaurevinylester	siehe Vinylacetat		
Ethanol	siehe Alkylalkohole		
Ether	siehe Diethylether		
2-Ethoxyethanol		$C_4H_{10}O_2$	II
Ethylacetat		$C_4H_8O_2$	III
Ethylacrylat		$C_5H_8O_2$	I
Ethylamin		C_2H_7N	I
Ethylbenzol		C_8H_{10}	II
Ethylchlorid	siehe Chlorethan		
Ethylenglykol		$C_2H_6O_2$	III
Ethylenglykolmonoethylether	siehe 2-Ethoxyethanol		
Ethylenglykolmonomethylether	siehe 2-Methoxyethanol		
Ethylglykol	siehe 2-Ethoxyethanol		
Ethylmethylketon	siehe 2-Butanon		
Formaldehyd		CH_2O	I
2-Furaldehyd		$C_5H_4O_2$	I
Furfural, Furfurol	siehe 2-Furaldehyd		
Furfurylalkohol		$C_5H_6O_2$	II
Glykol	siehe Ethylenglykol		
Holzstaub in atembarer Form			I
4-Hydroxy-4-methyl-2-pentanon		$C_6H_{12}O_2$	III
2.2'-Iminodiethanol		$C_4H_{11}NO_2$	II
Isobutylmethylketon	siehe 4-Methyl-2-pentanon		
Isopropenylbenzol		C_9H_{10}	II
Isopropylbenzol		C_9H_{12}	II
Kohlenstoffdisulfid		CS_2	II
Kresole		C_7H_8O	I
Maleinsäureanhydrid		$C_4H_2O_3$	I
Mercaptane	siehe Thioalkohole		
Methacrylsäuremethylester	siehe Methylmethacrylat		
Methanol	siehe Alkylalkohole		
2-Methoxyethanol		$C_3H_8O_2$	II
Methylacetat		$C_3H_6O_2$	II
Methylacrylat		$C_4H_6O_2$	I
Methylamin		CH_5N	I
Methylbenzoat		$C_8H_8O_2$	III
Methylchlorid	siehe Chlormethan		
Methylchloroform	siehe 1,1,1-Trichlorethan		
Methylcyclohexanon		$C_7H_{12}O$	II
Methylenchlorid	siehe Dichlormethan		
Methylethylketon	siehe 2-Butanon		
Methylformiat		$C_2H_4O_2$	II
Methylglykol	siehe 2-Methoxyethanol		
Methylisobutylketon	siehe 4-Methyl-2-pentanon		
Methylmethacrylat		$C_5H_8O_2$	II
4-Methyl-2-pentanon		$C_6H_{12}O$	III
4-Methyl-m-phenylendiisocyanat		$C_9H_6N_2O_2$	I
N-Methylpyrrolidon		C_5H_9NO	III
Naphthalin		$C_{10}H_8$	II
Nitrobenzol		$C_6H_5NO_2$	I
Nitrokresole		$C_7H_7NO_3$	I
Nitrophenole		$C_6H_5NO_3$	I
Nitroluole		$C_7H_7NO_2$	I
Olefinkohlenwasserstoffe (ausgenommen 1.3-Butadien)			III
Paraffinkohlenwasserstoffe (ausgenommen Methan)			III
Perchlorethylen	siehe Tetrachlorethylen		
Phenol		C_6H_6O	I
Pinene		$C_{10}H_{16}$	III
2-Propenal		C_3H_4O	I
Propionaldehyd		C_3H_6O	II
Propionsaure		$C_3H_6O_2$	II
Pyridin		C_5H_5N	I
Schwefelkohlenstoff	siehe Kohlenstoffdisulfid		
Styrol		C_8H_8	II
1.1.2.2-Tetrachlorethan		$C_2H_2Cl_4$	I
Tetrachlorethylen		C_2Cl_4	II
Tetrachlorkohlenstoff	siehe Tetrachlormethan		
Tetrachlormethan		CCl_4	I
Tetrahydrofuran		C_4H_8O	II
Thioalkohole			I
Thioether			I
o-Toluidin		C_7H_9N	I
Toluol		C_7H_8	II
Toluylen-2,4-diisocyanat	siehe 4-Methyl-m-phenylendiisocyanat		
1.1.1-Trichlorethan		$C_2H_3Cl_3$	II
1.1.2-Trichlorethan		$C_2H_3Cl_3$	I
Trichlorethylen		C_2HCl_3	II
Trichlormethan		$CHCl_3$	I
Trichlorphenole		$C_6H_3OCl_3$	I
Triethylamin		$C_6H_{15}N$	I
Trichlorfluormethan		CCl_3F	III
Trimethylbenzole		C_9H_{12}	II
Vinylacetat		$C_4H_6O_2$	II
Xylenole (ausgenommen 2.4-Xylenol)		$C_8H_{10}O$	I
2.4-Xylenol		$C_8H_{10}O$	II
Xylole		C_8H_{10}	II

	elektriciteits-bedrijven		raffinaderijen		industrie-totaal		overige sectoren/ activiteiten[2]		alle sectoren/ activiteiten	
	S	e.f.	S	e.f.	S	e.f.	S	e.f.	S	e.f.
1975										
steenkool	1,14	875			1,1	770	1,0	650		
petroleum									0,042	19,6
HBO[3]									0,59	273
zware stookolie	2,17	1 055	4,0	1 950	2,63	1 280	2,63	1 280		
1976										
steenkool	1,1	845			1,1	770	1,0	650		
petroleum									0,037	17,3
HBO[3]									0,47	219
zware stookolie	2,0	975	3,6	1 755	2,5	1 220	2,5	1 220		
1977										
steenkool	0,9	690			1,1	770	1,0	650		
petroleum									0,037	17,3
HBO[3]									0,44	207
zware stookolie	1,65	810	3,4	1 660	2,4	1 180	2,4	1 180		
1978										
steenkool	0,82	630			1,1	770	1,0	650		
petroleum									0,037	17,3
HBO[3]									0,42	194
zware stookolie	1,52	745	3,6	1 755	1,93	940	1,93	940		
1979										
steenkool	0,62	480			1,1	770	1,0	650		
petroleum									0,037	17,3
HBO[3]									0,42	194
zware stookolie	1,58	770	3,6	1 755	2,05	975	1,74	850		
1980										
steenkool	0,85	655			1,0	700	1,0	650		
petroleum									0,019	9
HBO[3]									0,32	149
zware stookolie	1,49	727	2,65	1 295	1,76	860	1,76	860		
1981										
steenkool	0,87	670			1,0	700	1,0	650		
petroleum									0,018	8,4
HBO[3]									0,27	125
zware stookolie	1,52	750	2,60	1 270			1,53	750		

[1] Zwavelgehalte S in [gew. %]; emissiefactor e.f. in [g/GJ].
[2] Exclusief gas- en oliewinningsbedrijven en steenkoolcokesfabrieken.
[3] Inclusief halffabrikaten.

Bron: *Emissie door verbranding van fossiele brandstoffen in ovens 1975–1981* (CBS).

Parameter	Eenheid	Kwaliteitsklassen I A	I B	II A	II B	III A	III B
zuurgraad	pH-eenheden	7.0 – 8.5	–	6.5 – 9.0	–	6.5 – 9.0	–
kleurintensiteit	mg/l	–	20[1]	50	100[1]	–	200[1]
gesuspendeerde stoffen	mg/l	25	–	–	50[5]	–	–
temperatuur	°C	–	25[1]	25	25[1]	–	25[1]
geleidingsvermogen voor elektriciteit	mS/m bij 20 °C	100	–	100	–[1]	100	–
geur-verdunningsfactor bij 20 °C	–	3	–	16	–	20	–
chloride	mg/l Cl	150	–	200	–	200	–
sulfaat	mg/l SO_4	–	100	100	250[1]	–	250[1]
fluoride	mg/l F	–	1.0	1.0	–	1.0	–
ammonium	mg/l N	–	0.2	1.2	1.2	–	3[1]
organisch gebonden stikstof	mg/l N	1.0	–	2.5	–	3.0	–
nitraat	mg/l NO_3^-	–	25	50	50	–	50
fosfaat[3]	mg/l P	0.2	–	0.2	–	0.2	–
zuurstof opgelost[2]	mg/l O_2	> 6	–	> 5	–	> 4	–
chemisch zuurstofverbruik[2]	mg/l O_2	–	–	> 30	–	> 40	–
biochemisch zuurstofverbruik[2]	mg/l O_2	> 3	–	> 6	–	> 7	–
natrium	mg/l Na	90	–	120	–	120	–
ijzer opgelost[2]	mg/l Fe	–	0.3	0.5	2.0	0.5	–
mangaan[2]	µg/l Mn	50	–	500	–	500	–
koper	µg/l Cu	–	50[1]	50	–	50	–
zink	µg/l Zn	–	200	200	1.000	–	3.000
boor	µg/l B	1.000	–	1.000	–	1.000	–
arseen	µg/l As	–	20	20	50	–	50
cadmium	µg/l Cd	–	1.5	1.5	3	–	5
chroom	µg/l Cr	–	20	50	50	–	50
lood	µg/l Pb	–	30	30	50	–	50
seleen	µg/l Se	–	10	10	10	–	10
kwik	µg/l Hg	–	0.3	0.3	1	–	1
barium	µg/l Ba	–	100	200	1.000	–	1.000
cyanide	µg/l CN	–	50	50	50	–	50
oppervlakte-actieve stoffen die reageren met methyleenblauw	µg/l	200	–	200	–	500	–
met waterdamp vluchtige fenolen	µg/l C_6H_5OH	–	1	–	5	10	10
minerale olie	µg/l	–	50	200	200	–	1.000
polycyclische aromatische koolwaterstoffen	µg/l	–	0.2	0.2	0.2	–	1
organochloorpesticiden totaal	µg/l	–	0.05	0.1	0.5	–	0.5
organochloorpesticiden per afzonderlijke stof	µg/l	–	–	0.05	–	–	–
choline-esteraseremmers	µg/l	–	0.5	1.0	2.0	–	5.0
bacteriën van de coligroep (totaal)	mediaan per 100 ml[4]	20	–	–	–	–	–
thermotolerante bacteriën van de coligroep	mediaan per 100 ml[4]	20	–	2.000	–	20.000	–
faecale streptococcen	mediaan per 100 ml[4]	10	–	1.000	–	10.000	

SSR - PHASE I
EWP

RECHECKED
DOCUMENT

COMMENTS:

BY: 24/6/91

A8.

DUTCH QUALITY STANDARDS FOR FISH WATER

pH		6.5 - 9.0
Temperature increase	°C	< 3
Suspended solids	mg/l	< 50
Oil		Not visible
Phosphate (P)	µg/l	< 200
Ammonium (N)	mg/l	< 0.8
BOD	mg/l	< 10
Oxygen (O_2)	mg/l	> 6
Ammonia (N)	µg/l	< 20
Residual chlorine (HOCl)	mg/l	< 5
Nitrite (N)	µg/l	< 300
Copper (Cu)	µg/l	< 30
Zinc (Zn)	µg/l	< 200

SSR - PHASE I
EWP
RECHECKED DOCUMENT
COMMENTS:
BY 29/6/91

EC STANDARDS FOR DRINKING WATER

		Desirable Level	Permissible Level
Color	mg/l PT/Co	1	20
Turbidity	mg/l SiO_2	1	10
Temperature °C		12	25
pH		6.5 - 8.5	9.5
Conductivity	µS cm^{-1} (20°C)	400	
Chlorides	mg/l Cl	25	200
Sulfates	mg/l SO_4	25	250
Calcium	mg/l Ca	100	
Magnesium	mg/l Mg	30	50
Sodium	mg/l Na	20	150
Potassium	mg/l K	10	12
Aluminum	mg/l Al	0.05	0.2
Hardness	mg/l Ca	60 (minimum)	
TDS	mg/l		1500
Nitrates	mg/l NO_3	25	50
Nitrites	mg/l NO_2		0.1
Ammonium	mg/l NH_4	0.05	0.5
Kjehldahl-N	mg/l N		1
Dissolved HC	µg/l		10
Phenolic comp.	µg/l C_6H_5OH		0.5
Borium	µg/l B	1000	
Surface active compounds	µg/l (lauryl-sulfate)		200
Iron	µg/l Fe	50	200
Manganese	µg/l Mn	20	50
Copper	µg/l Cu	100	3000
Zinc	µg/l Zn	100	5000
Phosphor	µg/l P_2O_5	400	5000
Fluor	µg/l F^2 8-12°C		1500
	25-30°C		700
Barium	µg/l Ba	100	
Silver	µg/l Ag		10

<u>Toxic Substances</u>

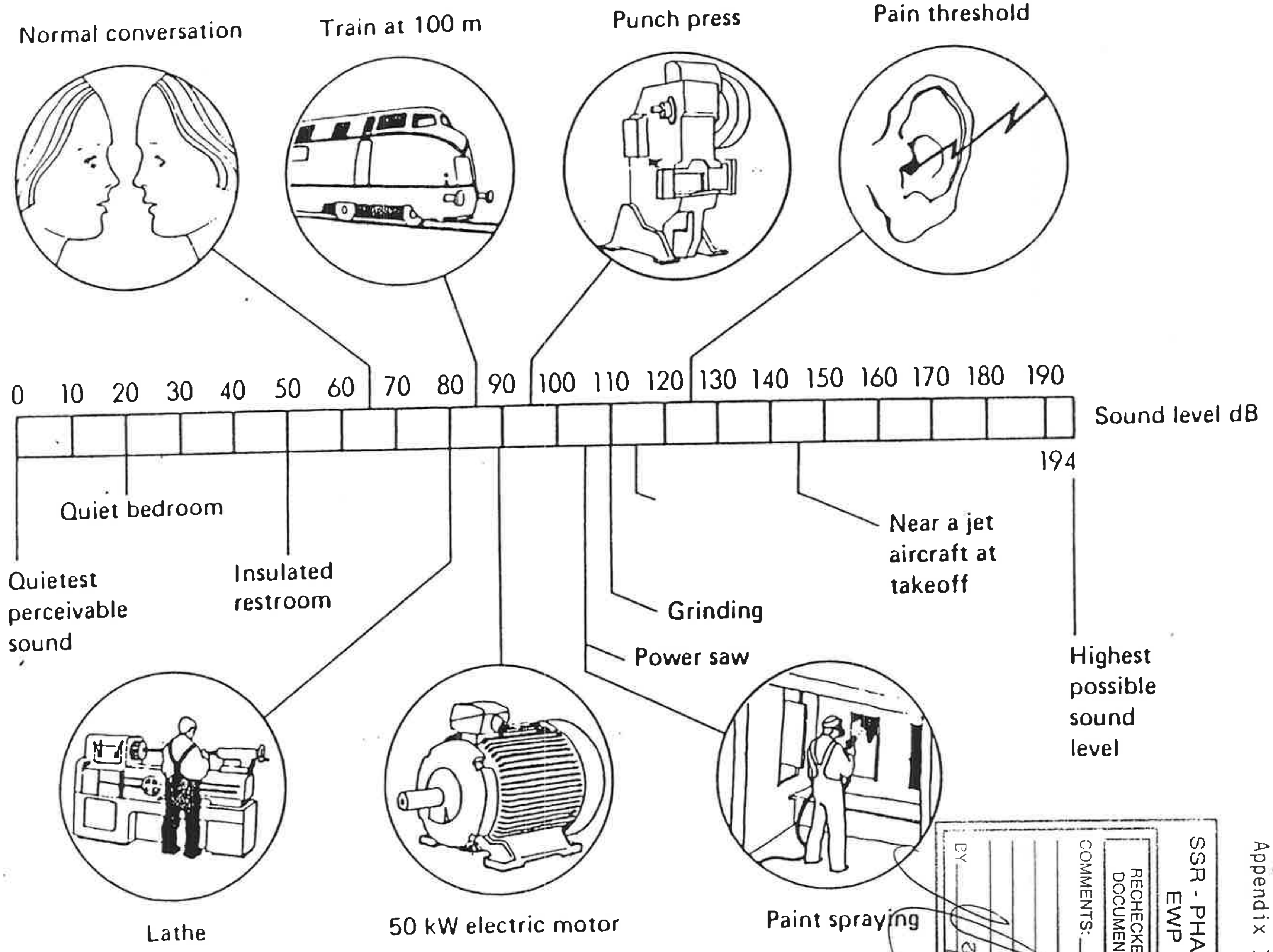
		Desirable Level	Permissible Level
Arsenic	µg/l As		50
Cadmium	µg/l Cd		5
Cyanides	µg/l CN		50
Chrome	µg/l Cr		50
Mercury	µg/l Hg		1
Nickel	µg/l Ni		50
Lead	µg/l Pb		50
Antimonium	µg/l Sb		10
Selenium	µg/l Se		10

WATER EFFLUENT LIMITATIONS

	USA kg/day (Note 1)	World Bank kg/1000 m^3 Feed (Note 2)	India kg/1000 Ton Feed	India mg/l	Saudi Arabia mg/l	Neth mg/l (Note 3)
BOD	27.4	7.5	10.5	15	25	7
COD	-	46.0	-	250	150	30
NH_3-N	-	5.0	-	50	1.0	1.2
TSS	18.9	5.0	14.0	20	15	≤ 50 (Note 4)
Phenol	0.04	0.05	0.7	1.0	0.1	-
Oil and Grease	8.6	-	7.0	10	8.0	
Sulfide	-	0.05	0.35	0.5	-	-
pH	6-9	6-9	-	6-8.5	6-9	6.5-9

Notes:

1. Absolute values for direct discharge.
2. Average of allowable values for topping and cracking.
3. Values for receiving surface water.
4. EC standards are 25 mg/l.


Normal conversation
Train at 100 m
Punch press
Pain threshold
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
Sound level dB
194
Quiet bedroom
Quietest perceivable sound
Insulated restroom
Near a jet aircraft at takeoff
Grinding
Power saw
Highest possible sound level
Lathe
50 kW electric motor
Paint spraying

RECOMMENDED ENVIRONMENTAL DESIGN CRITERIA

IMMISSION STANDARDS CONC (ug/m^3) (Yearly Average/Daily Average)

SO_x	100/1000
NO_x	100/-
CO	10000/-
Particulars	100/500

EMISSION ENGINEERING DESIGN GUIDELINES

SO_x	1.0	g/MJ
NO_x	130	mg/MJ
Particulates	100	mg/m^3

WATER EFFLUENT LIMITATIONS CONC (mg/l)

BOD	15
COD	250
NH_3-N	50
TSS	50
Phenol	1.0
Oil and Grease	10
Sulfide	0.5
pH	6-8.5

NOISE LIMITATIONS (sound pressure levels)

Inside plant (but at least one meter from equipment)	:	85 dB(A).
At nearest village	:	50 dB(A).