

**Health complaints  
& air pollution  
from the Isla refinery in Curaçao;**  
*with special emphasis  
to the response to irregular situations*

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1. Description of the area of investigation
2. C. Heggers: Advice of the Dutch Health Council on smog episodes, bureau MMK, GGD R'dam e.o. (in Dutch)
3. C. Heggers: Health base of relevant air quality standards, bureau MMK, GGD R'dam e.o.
4. American Industrial Hygienists Association: Emergency Response Planning Guidelines

## Summary

The Environmental Service of Curaçao (ESC) wants to improve the communication with the public as well as the attendance of health complaints. Health complaints may vary by nature, number and measure and may involve several levels of response. For example, irregular situations may require a collective response, i.e. incident management or disaster response. Irregular situations are the main focus of attention in this assignment. The response to irregular situations complements environmental measures for regular situations, but can never replace regular policies.

To further the response to health complaints and to irregular situations the following products were prepared:

- a) An information brochure for the general public
- b) Ascertainment of the attendance of health complaints from affected schools
- c) Installation of a consultative body for the attendance of complaints
- d) Start-up of a public alarm system with incidents & accidents at Isla

In order to realize these products a number activities were executed. Health complaints were inventoried from several relevant parties. All health complaints were considered relevant for the purpose of the information brochure. For the purpose of an ESC-response only those health effects were selected that were known to be related to refinery emissions. As a matter of fact only acute (and chronic intermittent) health effects could be considered within the realm of this assignment. However, the limitation to acute health effects strengthened the burden of proof considerably and made it possible to relate health effects to specific pollutants and pollution sources. The findings were discussed with relevant parties. Most conclusions could be reached in consensus. Recommendations were proposed to the ESC and to the tenant of the refinery (PdVSA). Some urgency was added to the recommendations, because of the finding that a number of irregular situations have caused acute health effects that warrant disaster response, i.e. immediate evacuation or shelter in place.

## PREFACE:

This report has been written rather matter-of-factly, but could also have been written as a medical detective. As is often the case in such stories the help of many was critical to the success. In fact all participating parties lend their cooperation and helped to find the clues. I want to thank all participants for their willingness to cooperate.

The only objection some participants made against this assignment was that there should be no need for a medical detective. and right they are! Medical expertise presupposes medical effects that should be prevented. So, why accept such an assignment and why cooperate with it ?

Well, for two main reasons: For one, medical expertise is generally required in case of public anxiety, because it can clarify which risks and health effects are real and which are not. In addition, medical expertise is specifically useful if regular policies are implemented (or at least put in motion) and irregular situations have to be dealt with as a complement.

## 1. Introduction

In the past years several efforts have been made to improve the environmental situation related to the refinery of Curaçao at Isla. In some respects the results are tangible: e.g. a nuisance license was issued in 1997 and emissions to the air were reduced through technical improvements such as steam atomization. In some respects results are still pending: e.g. the upgrading program for the refinery, a partly new and partly renovated BOO/CUC power plant and air pollution monitoring equipment<sup>1</sup>. The efforts and activities are not sufficiently visible to the public, however. Also more in general, the communication with the public concerning Isla needs to be improved in the opinion of the Environmental Service of Curaçao (ESC). The ESC wishes to improve the communication with the public and has initiated regular contact with the schools in the affected area. Initially the efforts have been focused on the attendance of complaints regarding health and nuisance. Petroleos de Venezuela S.A. (PdVSA), the tenant of the refinery, is willing to cooperate and has already started to respond to complaints of schools. The ESC has requested expert advice on the next step for improving the communication with the public and the response to health complaints. This report contains the requested advice.

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<sup>1</sup> The plans for the power plant follow a 'built, own and operate construction' (BOO). The plant is formally named 'Curaçao Utility Company' (CUC), but is more generally known as BOO. BOO/CUC is in the preparation phase. The decision phase has been completed (plans, design, specifications and contractor). The terms for the investment program for Isla have been specified in the 'Isla Refinery Upgrading Program', or IRUP. The IRUP-program is in the final design stages. The functional design has already been agreed upon some years ago (contract awarded to Foster Wheeler USA Corp.), the detailed design recently has been awarded to another firm. The necessary funds have been allocated by the participating parties, i.e. the Island of Curaçao (the most recent government compromise left the investments undisturbed) and the PdVSA has reconfirmed their participation in June (in the course of the visit).

## 2. General framework

Environmental policy generally follows two tracks: a source oriented track and an effect-oriented track.

The source-oriented track is focused on individual polluters, on prevention and on pollution abatement close to the source (1st line of defense). Examples in relation to Isla are the nuisance license for PdVSA and the inspections of the refinery.

The effect oriented track serves to keep a close watch of the state of environment and to protect against deleterious effects (2nd line of defense). Relevant examples for Curaçao are: an air pollution monitoring network and a set of air quality standards.

Complementary to these two policy-tracks relief organizations have to prepare a response to accidental emissions. The organization of disaster response (by the Fire Brigade) is an example in kind.

### Source oriented policy:

- . *Objective:* up to date and clean industry
- . *Instrument:* license + revisions
- . *Criterion:* technical state of the art

### Effect oriented policy::

#### - Regular emissions

- . *Objective:* acceptable exposures of public
- . *Instrument:* air pollution monitoring
- . *Criterion:* accepted risk levels & threshold levels for adverse health effects

#### - Irregular emissions

- . *Objective:* minimize exposure of public
- . *Instrument:* coordination or command structure
- . *Criterion:* acute/direct hazard to public health --> standard levels of alarm

*Scheme 2. 1: General framework for environmental policy*

This assignment only regards irregular emissions and situations (on several levels of concern). With this assignment the other activities of the ESC to improve the environmental situation (see introduction) are complemented.

## 3. Products

### 3.1 General

The response to environmental health complaints depends on the state of development of a society and of the technical possibilities of the environmental service.

For practical reasons the response to health complaints is considered to be part of a 'response-scale' ranging from public information to incident management & disaster response.

In view of the state of affairs at Curaçao the following steps and products are proposed:

- a) An information brochure for the general public
- b) Ascertainment of the attendance of health complaints from the affected schools
- c) Installation of a consultative body for the attendance of complaints
- d) Start-up of a public alarm system with incidents & accidents at Isla

The framework, target group, scopes and objectives of the products are described below.

### 3.2 Information brochure:

- *Framework*: Public awareness is an important instrument in societal development.

Awareness is especially important in issues driven by public opinion such as public health and environmental care. The Curaçao society is informed to some extent of the developments at Isla, but lacks sufficiently substantiated information of the impact of refinery emissions on public health. Nevertheless, awareness, especially of the public in the affected area, is conditional to a rational evaluation for attending health complaints and the like.

- *Target group*: The public at large and in the affected area in particular, governmental bodies/workers, non-governmental organizations (n.g.o.'s), refinery bodies<sup>2</sup>/workers, decision-makers etc.

- *Scope*: To date, no governmental air pollution monitoring network is yet in place in Curaçao. Also data submitted by the refinery are limited. Consequently, the brochure is restricted to a qualitative overview by type of pollutant.

The types of refinery emissions to the air and their risks to public health are known in general. A general overview of potential health effects is thought to be representative for Isla. The production pattern of PdVSA and past measurements of air quality give no indications of the presence of other - atypical - pollutants.

- *Objective*: To serve as (objective) information about the public health impact of Isla.

### 3.3 Attendance of health complaints from schools

- *Framework*: The ESC has rather limited capacity and capability to respond to complaints. PdVSA already responds to complaints of schools. Direct contact between plaintiffs and large industries can be fruitful, if integrated in a quality management system. PdVSA is in the initial stages towards a quality system<sup>3</sup>. In this respect it is of mutual interest to build up a good relationship.

- *Scope*: To date it is not customary to complain about Isla. Moreover, the response to such complaints generally was not very satisfactory. As a consequence, the advice is restricted to the first steps towards a more effective response. These first steps are chosen in view of the local state of affairs. The first steps are directed at the schools and do not include the

<sup>2</sup> Isla is owned by the island of Curaçao. A governmental organization, the Refinery of Curaçao, serves as administrator (RdK). PdVSA currently is the tenant.

<sup>3</sup> PdVSA strives for ISO-9000 certification, but not yet for ISO-14000 certification.

neighborhood residents at this stage. There are several reasons for this choice. For one the schools have a high level of organization (enables direct contact with management and screening of complaints by the staff). Also children form a relatively susceptible part of the population. In addition, schools are instrumental in the dissemination of information in the neighborhood.

- *Target group:* Schools (children & staff) in the affected area

- *Objective:* The short-term objective is to consolidate the still fragile contacts between the schools and PdVSA. The long-term objective is to make a start with a more encompassing response system and to pave the way for a good relationship between the refinery (owner and tenant) and its neighbors.

### **3.4 Consultative body for health complaints**

- *Framework:* PdVSA receives most of the health complaints from schools in the affected area. As effective contacts are still fragile and as the attendance of complaints is dealt with directly between industry and those who complain, a consultative body including the authorities is warranted (see above).

- *Scope:* The schools are now working together and have an informal steering committee. The authorities recognize that the schools are a stakeholder and as such form a party, but have not yet initiated formal consultation of the schools on a regular basis. Further organization and unison of the schools is needed, so that they may operate as one party, but is not part of this assignment. The promotion of cooperation between stakeholders more in general, however, is part of this assignment. Within the realm of this project only advice is given on participants and function of a consultative body.

- *Target group:* The management of schools in the affected area, the administrator and the tenant of Isla, health and environmental authorities.

- *Objective:* The short-term objective is fine-tuning of the response to health complaints from schools. On longer term the body may prove of use for signaling policy issues and setting priorities for investments for the refinery. Logically, the consultative body should also have a role with the dissemination of information about Isla more in general.

### **3.5 Incident response system:**

- *Framework:* During the stay it became clear that the complaints exceeded the nuisance level and included disabling health effects. As a matter of fact schools in the affected area were wrestling with the question at what level of complaints the schools should be closed for the rest of the day. As a consequence it was decided to extend the project to incident management. As Isla is the dominant risk factor for the neighboring area, specific consideration of incidents and accidents at the refinery seems justified and worthwhile.

- *Scope:* The treatment of incident management and disaster response can only be very limited within this project. The advice is only concerned with the initial steps for setting up a health monitoring system for accidental releases.

- *Target group:* Population in affected area, both residents, schools etc.

- *Objective:* Start-up of a source-specific alert and response system for Isla.

## 4. Definition of study parameters

### 4.1 Area of investigation

The area affected by refinery emissions to the air has been described by the ESC as to neighborhood<sup>4</sup>.

In this study special attention is given to schools. Schools in the affected area have been grouped into three geographical clusters:

- Wishi/Marchena
- Heintje Kool/Roosendaal
- Buena Vista

The schools in the area are summarized in appendix 1.

The air pollution situation is different for each cluster

- Wishi/Marchena is directly downwind from the main sources of air pollution and is impacted by air pollution on a continuous basis.
- Heintje Kool & Roosendaal are located next to Wishi/Marchena and suffer the main impact with wind directions that deviate somewhat to the north.
- Buena Vista is located next to the central part of the refinery complex and is impacted by pollution sources at surface level and with low wind speeds<sup>5</sup>.

### 4.2 Population

In the affected area there are well-established neighborhood organizations present:

- Neighborhood center Wishi/Marchena
- Don Bosco
- Neighborhood center Buena Vista

Special attention is given to the school population: employees and children alike.

During the visit meetings were held with the neighborhood organization of Wishi/Marchena and with the Steering group of schools. Complaints of the exposed population were also available from responses to a questionnaire held in Wishi/Marchena late 1997 and from complaint-forms of ESC for the schools in the affected area. The attendants to the meetings and the responses to the forms and questionnaire were considered as 'representatives of the exposed population'<sup>6</sup>.

### 4.3 Air pollution situations

Three situations of air pollution are distinguished:

- Regular emissions with regular weather conditions
- Regular emissions with unfavorable weather conditions
- Accidental or otherwise irregular emissions

<sup>4</sup> The tradewinds are steady enough to define the area downwind of the refinery unequivocally. The results have been published before in the Curaçao Health Study.

<sup>5</sup> Buena Vista also is downwind of the eastern part of the refinery, among which the main tank parks.

<sup>6</sup> The consistency of the reports gives confidence that the findings are also 'representative' for the exposed population.

## 5. General approach

### 5.1 Assessment process

Questions of environmental health may come in two ways. Either there is a search for the (potentially environmental) origin of some illness, or there is a search for the potential health impact of some environmental factor.

<b>Starting point</b>	<b>Question</b>	<b>Method</b>
Environmental factor	Health impact?	1. Source inventory 2. Exposure assessment 3. Risk assessment
Illness	Environmental origin?	1. Health assessment 2. Exposure assessment 3. Source apportioning

Scheme 5.1: Working methods in environmental health:

In most cases it is possible to study environmental factors before they lead to health effects. In that case measurements are made in relevant media (soil, water, air, food), human exposures are estimated and health risks are derived and compared to health based standards in order to judge the acceptability of the situation.

**Source --> Exposure --> Impact --> Evaluation --> Response**

In some cases health effects give cause to research into a potential environmental origin. In such cases it is necessary to reason backwards from health effects to exposures and sources and to respond on that basis.

**Impact --> Effect --> Source --> Evaluation --> Response**

In the case of Isla in principle a health risk assessment should be performed to estimate the health impact. By lack of sufficient air pollution measurements, however, such a risk assessment could not be performed. Therefore, the inverse approach was chosen starting with a health assessment and reasoning back to refinery pollutants and to air pollution sources:

## 5.2 Health assessment

The health situation was evaluated through semi-structured interviews with relevant parties<sup>7</sup>. Chronic disorders as well as acute health complaints were asked for.

For chronic disorders the common knowledge was verified (health impact of refinery emissions to the air in general). No effort was put into a formal analysis<sup>8</sup>.

With respect to the acute health complaints the objective was to underpin the findings by looking for in-consistencies. Some criteria are listed below (see scheme 3).

<b>Consistency</b>	<b>Exemplary criteria</b>
<i>In time &amp; space</i>	Comparison of prevalence of symptoms within and outside the area (between persons) Course of symptoms with schoolchildren after leaving the area (within persons) Correspondence of symptoms with known occasions of high levels of air pollution
<i>With refinery emissions to the air</i>	Similarity with 'expected' health effects in general and with the main pollution sources at different sites in particular Occurrence of symptoms with increased odor intensity
<i>Over respondents</i>	Similarity of (esp. written) complaints among respondents Similarity of findings in different interviews
<i>With other clinical signs and symptoms</i>	Sequence of symptoms for the expected toxic process Combination of symptoms for the indicated degree of severity Completeness of expected clinical complex of symptoms Absence of non-expected symptoms
<i>With other types of effect</i>	Visual & odor perception Effects on materials

Scheme 5.2: Selected criteria of consistency of complaints of acute health effects from Isla

Actually, the health situation was assessed in a rather informal manner. The consistency was analyzed more or less systematically in every relevant instance, but no formal scoring system was developed<sup>9</sup>.

<sup>7</sup> Neighborhood representatives from Wishi/Marchena, Steering group of schools, General practitioners at Wishi/Marchena, Lungpediatrician, Occupational health department, Youth health department. Further information from various sources: Information from the Housing department about the number and medical grounds for allotting another house outside of Wishi/Marchena, survey publications from Epidemiological department, logbook of health complaints from schools, neighborhood questionnaire with health complaints in episode with increased levels of air pollution and fire in the refinery (october 1997).

<sup>8</sup> The causes of chronic disorders are difficult to proof, e.g. smoking and lung cancer. In the absence of air pollution monitoring data it made no sense to make a formal assessment of the local situation.

<sup>9</sup> Indeed, the overall picture came out so clear that a formal analysis would be 'overkill'.

In addition, the objective was to set up a response system in cooperation with the stakeholders.

### **5.3 Assessment of exposures and pollution sources**

Exposures and pollution sources were only assessed for acute health effects.

For an exposure assessment the types and levels of exposure need to be known<sup>10</sup>. The levels of exposure are put into perspective in chapter 6: scaling of acute health effects.

Here the stepwise elucidation of the types of air pollutants and their main sources is described.

First a number of pollutants was selected by combining the clinical complexes encountered with the general knowledge of refinery emissions<sup>11</sup>.

Then the preliminary conclusions were discussed with a number of relevant parties<sup>12</sup>.

From these discussions final conclusions were drawn, generally in consensus.

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<sup>10</sup> In general also the routes of exposure and exposures in different microenvironments need to be dealt with. However, the impact of refinery emissions on human health comes primarily from air pollution. Given the limited scope of this project, it seemed justified to consider only air pollutants.

Also, it is less useful to distinguish between ambient air, indoor air and other microenvironments in poor neighborhoods of tropical countries. Residents and schools in the affected area of Isla do not in general have air conditioning.

<sup>11</sup> In fact, the health effects could be related to a rather small group of pollutants. This gave further confidence in the validity of the findings.

<sup>12</sup> Most notably, the Administrator of Isla (RdK), the environmental office of PdVSA and the refinery inspectors of the ESC. The discussions with RdK and PdVSA were mostly focussed on pollution sources, with the ESC also the types of pollutants were discussed elaborately.

## 6. Health Complaints

### 6.1 General

The interviews resulted in a rather complete picture of acute health effects. In most cases acute signs and symptoms were reported spontaneously. The remainder of this report is concerned with this type of health effects.

Chronic disorders were seldom reported spontaneously, except for asthma and other Chronic Obstructive Pulmonary Disorders (COPD)<sup>13</sup>. In addition the medical professionals were worried about the long-term consequences of soot deposition in the lungs. Also, one representative of the exposed population was worried that Isla was the caused of many common child diseases incl. mental disorders, intestinal problems, infectious diseases a/o. Chronic disorders form an important subject in the information brochure, but are not treated in this report, except for acute exacerbations of asthmatic symptoms.

### 6.2 Acute health effects

Predominantly three clinical complexes of acute health effects were reported:

- a) Irritation of skin & mucous membranes
- b) General indisposition
- c) Increase of signs & symptoms of COPD

Some other health effects that were mentioned require separate consideration, because they are linked only partly or indirectly with refinery emissions, or result from chronic exposure:

- i. Mucus production
- ii. Respiratory infections

#### a. Irritation of skin and mucous membranes

<b>Irritation of skin &amp; mucous membranes</b>	
<i>Eyes</i>	Red/injected conjunctiva, lacrymation
<i>Nose</i>	Red, painful, dry; running, swollen or clogged nose
<i>Throat</i>	Tinging, dry, sore throat
<i>Respiratory tract</i>	Coughing, dyspnea
<i>Skin</i>	Reddish, itching <sup>14</sup>

Scheme 6.1: Reported signs and symptoms of irritation of skin and mucous membranes

Signs of irritated mucous membranes were spontaneously reported by the representatives of the exposed population (scheme 6.1). The occurrence of symptoms was consistently and consequently related to instances with increased odor intensities and a chemical mist. In most cases the representatives could also distinguish between the different types and degrees of irritation:

- sometimes most notably involving the eyes, sometimes rather the respiratory tract,
- occasionally leading to coughing and/or skin irritation.

It is not customary, however, to pay a visit to the doctor for this kind of health effects.

<sup>13</sup> COPD (Engl.) = CARA (Dutch)

<sup>14</sup> All representatives of the exposed population also reported upflares of allergy, but actually meant skin problems more in general. There were no indications among the medical professionals that allergy is very prevalent at Curaçao. Neither do refinery emissions to the air more in general give cause to allergies (but may provoke hypersensitive reactions).

## b. General indisposition

<b>General indisposition:</b>	
<i>Digestive system</i>	Nausea, vomiting
<i>Central Nervous system (CNS)</i>	Headache

Scheme 6.2: Reported signs and symptoms of general indisposition

Several signs and symptoms of general indisposition were spontaneously reported for instances with increased odor intensities and with chemical mists. All interviewed persons reported nausea from the smell. Some persons also reported vomiting. In addition for Wishi/Marchena there was mention of the combination of nausea with headache that lasted for many hours. Also there was one case report of vomiting followed by a headache for almost two days.

Such symptoms often lead to a request for sick leave, at least among schoolchildren, but do not lead to doctor's visits.

## c. Exacerbation of asthma and COPD

All those interviewed, professionals and lay persons alike, spontaneously reported an increase of symptoms esp. dyspnea among asthma and COPD patients in periods with calm weather conditions. Such periods also lead to an increase in doctor's visits by asthma/COPD patients.

### Ad i. Mucus production

All representatives of the exposed population reported increased, thick or tough mucus in nose and throat. Acute exposure to respiratory irritants may cause rinorrhea, but generally do not result in thick or tough mucus. This type of symptoms is more typical for chronic or at least remittent exposure to irritants.

### Ad ii. Respiratory infections

Representatives of the exposed population also reported recurrent respiratory infections. No relation with specific periods was mentioned. This makes the reports more credible, but makes it also clear that a relation with the refinery is hard to prove. Only a general statement can be made that the alteration of the mucus production may have a negative effect on the resistance to upper respiratory infections (URI)<sup>15</sup>.

## **6.3 Related air pollutants and pollution sources**

The above mentioned complexes of health effects can be related to distinct groups of air pollutants that are common to refinery emissions and that are known problems at Isla. The degree of acute health effects from irregular situations, however, appeared to be much more serious than expected<sup>16</sup>. The only possible explanation is a relatively high 'preload' from (related) regular emissions to the air. Preloading factors differ for the various health effects and are considered at the respective sections.

### a. Irritation of skin & mucous membranes:

Many of the regular emissions to the air involve respiratory irritants, most notably sulfur

<sup>15</sup> Nitrogen dioxide is known to increase the prevalence of URI's. However, the levels of nitrogen dioxide encountered in the affected area are not very high.

<sup>16</sup> Both general presence and severity of effects are implied.

dioxide, nitrogen dioxide, ozone and particulate matter. Intermittent emissions of cat cracker dust may be an additional burden to the respiratory tract<sup>17</sup>.

The respondents mentioned that the acute irritative effects generally were accompanied by a visible heavy mist with a smell of rotten eggs or onions. This is a clear indication that accidental emissions of sulfur-related acid compounds are involved. There are also consistent reports that metals turn black and corrode very fast (compared to other parts of the island)<sup>18</sup>, which also indicates sulphur-related acids. Hydrogen sulfide (H<sub>2</sub>S) probably is the main constituent of the mists (heavy gas, rotten egg odor), but also mercaptans (onion like smell) and oxydated (and perhaps corrosive) acids (H<sub>2</sub>S oxydates rapidly and does not irritate the skin) are present.

Sources of hydrogen sulfide and related compounds are esp. the sulfur recovery units (SRU)<sup>19</sup>. SRU's are very sensitive to disturbing factors and need to be taken out quite often. Problems with the SRU's are acknowledged by PdVSA and are part of the upgrading program for Isla<sup>20</sup>.

#### b. General indisposition:

General indisposition is not specific for air pollution, but may be caused by all kinds of mishaps. In relation to air pollution especially odorous substances may have a nauseating effect<sup>21</sup>. Many odorous substances may cause nausea and even vomiting as a reflex reaction. A few substances, however, may cause nausea and vomiting by a specific toxic effect on the intestinal tract. Most notably many hydrocarbons have such an effect.

The fact that volatile hydrocarbons are involved was substantiated in several ways:

- Several respondents reported that two different types of mist might occur. Apart from the sulphur-related mist there was mention of a blue oily haze. Such a haze corresponds well with hydrocarbons.
- Representatives of the population reported collective headaches in relation to the occurrence of such a chemical mist. Headaches by themselves are very indiscriminate as symptom and may also occur as a reflex reaction to harmful substances. However, headache may also be a symptom of general suppression of the Central Nervous System (CNS). Many fat-soluble substances suppress the brain functions, among which many hydrocarbons<sup>22</sup>.

One written case report even mentioned that a school girl had a 'hang-over' for almost two days after being sent home for vomiting.

The preload of volatile hydrocarbons is also quite high at Isla. Apart from the regular emissions that are generally high with old plants like at Isla<sup>23</sup>, there are specific problems with the final oil catchers and with old spills that have been left unattended. Furthermore, PdVSA plans to start with landfarming for polluted soil, adding another source of hydrocarbons to the

<sup>17</sup> Especially adsorption of (and hence enrichment with) vanadium (V) and its oxides enhance the irritative properties.

<sup>18</sup> Metals corrode quickly everywhere on Curaçao because of aerosols with sea salt (esp. the nitrate-content). Nevertheless, comparisons between different places on the island can be easily made.

<sup>19</sup> The flares may also be a source of hydrogen sulfide, but generally only in small amounts.

<sup>20</sup> Some interviewed persons were doubtful whether the level of upgrading of the SRU's would be sufficient.

<sup>21</sup> This is a rather common reflex reaction of the body to defend itself against harmful factors.

<sup>22</sup> Fat-soluble (lipophilic) substances can pass the blood-brain-barrier and affect the brain-cells. Narcotics, anesthetics, alcohol and other agents have a general suppressive effect on the functioning of the brain.

<sup>23</sup> Old plants have many pipelines with a relatively high probability of leaking flanges. Also the tankroofs are generally not protected against evaporative losses. Part of the tank park will be improved (internal floating roofs) as part of the upgrading program for the refinery.

most impacted site<sup>24</sup>.

The burden of volatile hydrocarbons may be further augmented by the (generally small) spills that occur every now and then during operations and by unfavorable weather conditions. Indeed, the reports of general indisposition concentrated on episodes of unfavorable weather conditions.

### c. Increase of signs & symptoms of asthma /COPD

Asthma/COPD patients are a vulnerable group for air pollution in general and are a recognized high-risk group for several specific refinery emissions to the air. It concerns esp. sulfur dioxide and fine dust, as well as nitrogen dioxide. These are the main air pollutants from refineries, but also from other sources, are emitted on a regular basis and pose a threat to ambient air quality in many situations and countries.

Air quality standards for these substances take the consequences for asthma/COPD patients specifically into account<sup>25</sup>. The prevalence of asthma and COPD has not been surveyed, but according to the local lung pediatrician it probably is on about the same level as in Europe and the Netherlands: that is 10 –15 % of children up to about 18 years<sup>26</sup>.

Exceeding of air quality standards may occur with unfavorable weather conditions and are likely to lead to an increase of signs and symptoms in asthma/COPD patients (see also next chapter)<sup>27</sup>. Indeed, both representatives of the exposed population and medical professionals related the increase of symptoms to periods of unfavorable weather conditions.

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<sup>24</sup> Polluted soils have to be cleaned for the building activities related to the new power plant and to the upgrading program. In addition, for improvement and maintenance of the oil endcatchers it is necessary to dredge up polluted sludge.

The land-farming site selected by PdVSA is close to the most leeward part of the Schottegat where all oil gathers that passes the official endcatchers or seeps out of polluted soil. In effect, this site just opposite of the Nijlweg at Wishi/Marchena serves as a natural oil endcatcher in its own right.

<sup>25</sup> The air quality standards take account of asthma/COPD, but do not protect against all effects and not for all patients. This holds esp. for fine dust, for which it is currently doubted that a threshold for effect exists.

<sup>26</sup> The Curaçao health study (early '90's) included asthma/COPD. The reported prevalences in adulthood were lower than in the Netherlands (4% vs. 6%). However, this survey only involved self-reporting which is very likely to have resulted in underreporting for this disease.

<sup>27</sup> Asthma/COPD has been the subject of heated debate in Curaçao.

## 7. Levels of health effects and of government responses

### 7.1 General

#### a. Introduction

Episodes of increased levels of air pollution may result in exceeding of air quality standards for hours or days. Accidental escapes of pollutants may result in acute exposures at hazardous levels for minutes to hours or more. In both cases measures have to be taken to minimize the exposures (see chapter 2: general framework).

Most of the time different regimes for taking measures are followed, however. For example, episodes of unfavorable weather conditions can be predicted in advance and exceeding of air quality standards can generally be prevented or at least minimized by lowering industrial activities in time. Accidental escapes of pollutants cannot be prevented, but a fast response and combating at the source may prevent for worse.

Also the level of response, among which the response of the authorities, varies with the level of health effects. The public should be notified as soon as possible of situations with increased health risk or possibly resulting in public disturbance. Depending of the level of health risks the public should be:

- given the opportunity to take suitable measures on an individual basis,
- urged to follow a general guideline (most of times behavioral codes<sup>28</sup>),
- told to follow the orders of the authorities

#### b. Episodes of unfavorable weather conditions

If unfavorable weather conditions lead to exceeding of air quality standards, the protection of public health cannot be guaranteed anymore and measures for the public should be taken (appendix 2). A committee of the Dutch Health Council has predicted the consequences of such circumstances (appendix 3, in Dutch).

#### c. Accidental emissions of air pollutants

For acute accidental escapes of toxins to the air a severity scale with '4D's' has come into international practice during the last decade (appendix 4). This scale is generally used as basis for intervention-levels. In the Rhine estuary the following intervention levels are employed (see scheme 7.1). Instantaneous information to the public is considered at pollution levels (and upward) that may provoke discomfort (guideline level). Acute public alarm is issued at pollution levels that may engender disability (threshold level). Public alarm implies either shelter in place or evacuation.

<sup>28</sup> For example to stay indoors, refrain from exercise in the open air, discontinue festivities etc.

<b>Effect level</b>	<b>Public notice</b>	<b>Response organization</b>
<i>Detection</i>		
<i>Discomfort</i>	Information guideline level	
<i>Disability</i>	Alarm threshold level	Contingency planning criterion
<i>Death</i>		Contingency planning criterion

*Scheme 7.1:* Relation between levels of health effects and levels of intervention as defined for the Rhine estuary (Rotterdam-Rijnmond).

To date a number of lists with standard values are in use (see scheme 7.2). At the moment efforts are underway to join forces. Oldest and most used is the ERPG-list (currently > 80 substances). The Rhine estuary list (incorporates the ERPG-values and) contains by far the most substances (> 270 substances divided into 2 hazard classes).

<b>Acronym</b>	<b>Name</b>	<b>Organization</b>
<i>ERPG</i>	Emergency Response Planning Guidelines	American Industrial Hygienist Association
<i>AEGL</i>	Acute Emergency Guideline Levels	US Environmental Protection Agency
<i>A/B-list</i>	Rhine estuary list	Disaster response organization for the Rotterdam-Rhine estuary region

*Scheme 7.2:* Lists of emergency response values for acute inhalatory intoxication

## **7.2 Curaçao & Isla**

### **a. Acute health effects**

The reported health effects are classified according to the '4D-system' in scheme 7.3. Health effects up to the disability level are reported to occur regularly, both from irritants and from hydrocarbons:

- Detection: almost continuously;
- Discomfort: almost daily;
- Disability: several times during a year with unfavorable weather conditions and with larger accidents such as the fire in October 1997;
- Death level: about one death of a refinery worker every ten years from a hydrogen sulfide escape.

Level of health effects	Irritants	Hydrocarbons
<i>Detection</i>	Odor recognition Visible haze/mist	Odor recognition Visible haze/mist
<i>Discomfort</i>	Red eyes, minor lacrymation Tinging dry throat	General indisposition: Minor nausea Individual minor headaches
<i>Disability</i>	Coughing, dyspnea	Vomiting Collective headaches
<i>Death</i>	Lungedema (ARDS)	Narcosis

*Scheme 7.3:* Classification of health effects reported in relation to Isla according to the '4D-system'.

#### a. Episodes of unfavorable weather conditions

In Curaçao refinery emissions may evoke smog situations<sup>29</sup>. Judging from the reported health effects unfavorable weather conditions repeatedly cause a level 3-alarm phase. Exceeding of air quality standards can be relatively easily prevented or at least minimized by reducing refinery emissions to the air temporarily.

The exceeding of air quality standards in the area affected by Isla is not limited to the general ambient air pollutants, but also concerns hydrocarbons. The reported health effects of hydrocarbons clearly surpass alarm level 3 and are in fact at the disability level related to disaster response. However, disaster response is meant for accidental emissions that can be combated at the source, which is not the case here. Clearly, structural measures that eliminate the most burdensome sources of hydrocarbons are required.

#### b. Accidental emissions of air pollutants

Accidental and other irregular emissions to the air occur every now and then as a result of refinery operations.

Most irregularities involve minor emissions causing discomfort for some period of time (estimated frequency: weekly to monthly). Complaints should be attended and information to the public should be considered with the more substantial emissions.

The disability level is only reached with larger scale accidents. The past five years several such accidents have occurred. Immediate response to protect the public in the threatened area is required. This type of response is best handled within the framework of the disaster response system. In Curaçao, as in many other countries, the Fire Brigade is primarily responsible for disaster response. For Isla specific arrangements seem worthwhile for several reasons:

- The refinery is a rather dominant and very visible hazard (certainly for the affected area).
- The opportunities to protect the public by sheltering in place are minimal (certainly in a poor area without many air-conditioning such as Wishi/Marchena).
- The hazard assessment after an accidental escape can be speeded up considerably by making systematic use of health complaints.

<sup>29</sup> Most relevant for Curaçao is smog from sulfur oxides and/or particulate matter.

## 8. Response to acute health complaints:

### 8.1 Levels of response

For practical reasons the response to health complaints about Isla is considered as part of a 'response-scale' involving respectively:

- Public information
- Communication with stakeholders
- Attendance of individual health complaints
- Incident management
- Disaster response

The response scale applies to the phases of preparation, acute response and follow up. Preventive measures, such as for episodes of unfavorable weather conditions are not included<sup>30</sup>.

### 8.2 Public information and communication

The ESC has a central role in the information for and communication with the public on environmental issues. However, ESC has little manpower left for such activities and even less so for activities concerning Isla specifically. In view of this state of affairs ESC has taken a facilitary, rather than an intermediary perspective. Activities so far in relation to Isla have been:

- arrangements with PdVSA to notify the public in advance of activities that may result in discomfort,
- an information brochure about the health impact of Isla: to be drafted in conjunction with this report,
- installation of a steering committee of schools.

#### *Recommendations*

These initial steps form a good start for building up confidence between parties. Confidence is conditional to almost every relation and should be adequately established before elaborating the relationship. To date the confidence basis between the parties involved is very fragile and needs to be strengthened considerably before taking any further steps. Most effort should be spent on improving the conditions for the arrangements already set in motion:

- Make the public understand why they are notified in some cases and in other cases not and take into consideration to notify the public afterwards of some of these 'other cases'.
- Keep a close watch of the way that the information brochure is received and be prepared to devise a course of action upon the feedback.
- Strengthen the cooperation between schools and the consultative body by bringing in the health authorities (occupational and youth departments) and the tenant (PdVSA) and manager (RdK) of the refinery.

### 8.3 Attendance of individual complaints

Health complaints of schools are attended by PdVSA. PdVSA has a fixed contact person for the attendance of complaints from the affected area. The ESC receives a weekly logbook of

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<sup>30</sup> The complete 'safety chain' consists of 5 phases: proaction - prevention - preparation - repression - aftercare.

complaints from the schools (if relevant).

After working hours complaints are received by the central control room at Isla and are transmitted to the refinery officer on duty.

*Recommendations:*

The choice for the attendance of complaints through direct contact between plaintiff and polluter is a fundamental choice. Direct contact may be fruitful if incorporated into a quality management system, since this creates a win-win situation for all parties involved. The consequences of this choice are that:

- the choice for a quality management system is definitive and complete<sup>31</sup>,
- the process towards a quality management system is well defined and has noticeable progress for outsiders,
- some 'third party', e.g. the aforementioned consultative body, keeps a close watch at the process: in 1st instance to ensure that a win-win relation is realized and afterwards to intermediate in case of conflicts.

On short term it seems most important to guarantee a satisfactory attendance of complaints of the schools. In this respect it is advised to:

- improve the accessibility to incoming complaints: plaintiffs must have confidence that their complaint is heard and will be dealt with by the right person
- improve the feedback to complainers: plaintiffs want to know what the effect of their complaint was and how long it will take before the nuisance is over.
- use the consultative body for fine-tuning of the attendance of complaints

#### **8.4 Response to collective complaints**

Collective complaints can be of use to determine what level of response is required. Generally two levels are distinguished (see scheme 7.1):

- Discomfort level: notification of the public.<sup>32</sup>
- Disability level: disaster response.

To date no arrangements have been made to deal with collective complaints about Isla.

Neither is the ESC involved in disaster response.

The need for such arrangements is felt especially by the management of the schools in the affected area and by the health authorities. They try to answer the question: 'in what situations to close the school for the rest of the day'. During this assignment a proposal has been drafted.

*Recommendations:*

The system for attending health complaints of schools is the best available starting point for

<sup>31</sup> Complete implies: involving the primary processes and including environmental aspects.

The consequences of 'complete' are a/o.: (a) that all relevant workers become involved with the attendance of complaints and that not just one worker is given that responsibility and (b) that the attendance of complaints concerns all 'neighbors' and is not restricted to the schools.

<sup>32</sup> The party issuing the public notice may vary.

If it concerns a known accidental emission of some substance, generally the disaster response organization determines on the basis of instantaneous measurements whether the information guideline level is surpassed. If some irregularity becomes known by health complaints, the response depends on the receiver of the complaints. In the Rhine estuary e.g. the more serious health complaints are likely to be transmitted to the disaster response organization, whereas most other complaints are received by the DCMR environmental service. The DCMR maintains as criterion that 15 complaints about one subject constitute a 'wave of complaints' and warrant notification of the public.

setting up a response system for collective complaints<sup>33</sup>. The schools may serve as health monitoring stations for irregular situations at Isla<sup>34</sup>. Operational health effect criteria for public alarm have been proposed (scheme 8.1) but need to be further specified and formalized (by the health authorities<sup>35</sup>). Also alternative day-programs for the pupils need to be organized outside of the area. Finally, in cooperation with the disaster response organization, special arrangements need to be made for notification of the public and public alert, shelter in place and evacuation<sup>36</sup>.

Criteria	Level <sup>37</sup>	Remarks <sup>38</sup>
<i>Level of health effects<sup>39</sup></i>	disability	Coughing Vomiting Headache
<i>Number of effects at selected level within geographical cluster</i>	2 to be determined	Coughing/vomiting Headache
<i>Duration of exposure</i>	operational	Remaining school hours Expected duration of emissions

*Scheme 8.1: Health effect criteria for public alarm through complaints of schools*

Obviously, such a system is rather imperfect and should be expanded to the rest of the population on a reasonably short term<sup>40</sup>.

<sup>33</sup> Disaster response in most countries is organized by scaling up from normal operation. In other words the system has to be integrated as much as possible with the standing organizations.

<sup>34</sup> Restricting the monitoring function to irregular situations circumvents ethical issues.

<sup>35</sup> Formally the director of the Public Health Service (GGD) should adopt the criteria and let the Health Inspectorate (VoMil) test them.

<sup>36</sup> These are standard activities for disaster response organizations that can be specified for areas at high risk. E.g. in the Rhine estuary special facilities (bus-stops) and arrangements (with transport companies) have been made (by the police) for evacuating the population near the large industrial areas (Europoort/Botlek).

<sup>37</sup> The level of health effects is (for practical reasons) chosen higher than normal (standard values for alarm normally protect against these effects), consequently a rather low number of health effects is chosen. This cannot be done so easily with headaches (too subjective and too many other causes), consequently it is left to the steering group to choose a number somewhere between 5 and 10.

The duration of the exposure also has to be determined operationally on the basis of the remaining school time and the expected duration of emissions. Most standard values (see scheme 7.2) are specified for an exposure of 1 hr.

<sup>38</sup> Presence of health effects at the level of disability with a few persons implies the presence of health effects at the discomfort level with several persons. This has not been specified (as e.g. with the British alarm standards: 'Specified Levels of Toxicity' or SLOT), because the school staff screen the complaints and have many additional checkpoints (own experience, knowledge of the plaintiff).

<sup>39</sup> (Acute) irritation rather than (subacute) mucus production should be the cause of coughing. Vomiting is preferred above vomit, since it is somewhat more protective. Headache should be bilateral and oppressive rather than stinging or knocking.

<sup>40</sup> Schools are only open part of the day, week and year. Also, schools are not the only place where groups at high risk are concentrated: kindergartens, homes for the elderly and disabled etc.

But schools can be closed, whereas response measures for the population at large are not so easily devised and/or implemented.

## 9. Conclusions & Recommendations:

### 9.1 Conclusions

The inventory of health complaints about Isla has had rather remarkable results. Health complaints appear to be limited to a considerable extent to acute health effects from irregular situations. The reporting of complaints was remarkably consistent over respondents and leaves little doubt about the validity of the findings. The acute health effects encountered were more serious than expected, due to the fact that there is a considerable preloading of regular air pollution acting on the same target organs.

Acute health effects were reported that are beyond the levels for 'smog alarm', but fit in the health-scale for disaster response.

Serious acute health effects are reported to be common in periods of unfavorable weather conditions<sup>41</sup> and can be prevented by lowering or stopping emissions temporarily.

Otherwise, serious acute health effects are reported to occur only with large-scale disasters such as the October 1997 fire. The response to such and other less serious health complaints can be considered as a 'response scale' with interrelated measures including a/o: public information, attendance of health complaints and disaster response. The present response for the schools in the affected area already forms a good basis for building up a response system. The response can be considerably improved by structuring the attendance of complaints to a further extent and by using this system for setting up a public alert system related to Isla. Asthmatic children and persons with Chronic Obstructive Lung disorders (COPD) more in general are a group at high risk for the effects of air pollution. Placement on schools outside the area at young age offers the best perspectives for asthmatic children.

### 9.2 PdVSA

In a presentation to part of the management of PdVSA some further operational recommendations have been made:

1. Lower baseline levels (preload) of volatile hydrocarbons
2. Install hydrogen sulfide alarm monitors at the fence near Wishi/Marchena and use these for information and alarm of the public
3. Ensure switching possibilities for sulfur recovery units (SRU's)
4. Use health complaints in the development of a quality system
5. Study the levels of air pollution at night

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<sup>41</sup> Mostly wind still weather in the tornado season culminating into a temporary change of the Trade winds. Also the nighttime conditions (low wind speed, evening/morning inversion) warrant separate consideration.

## 10. Literature

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