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LIMITATION OF AIR POLLUTION BY INTERNAL COMBUSTION ENGINES

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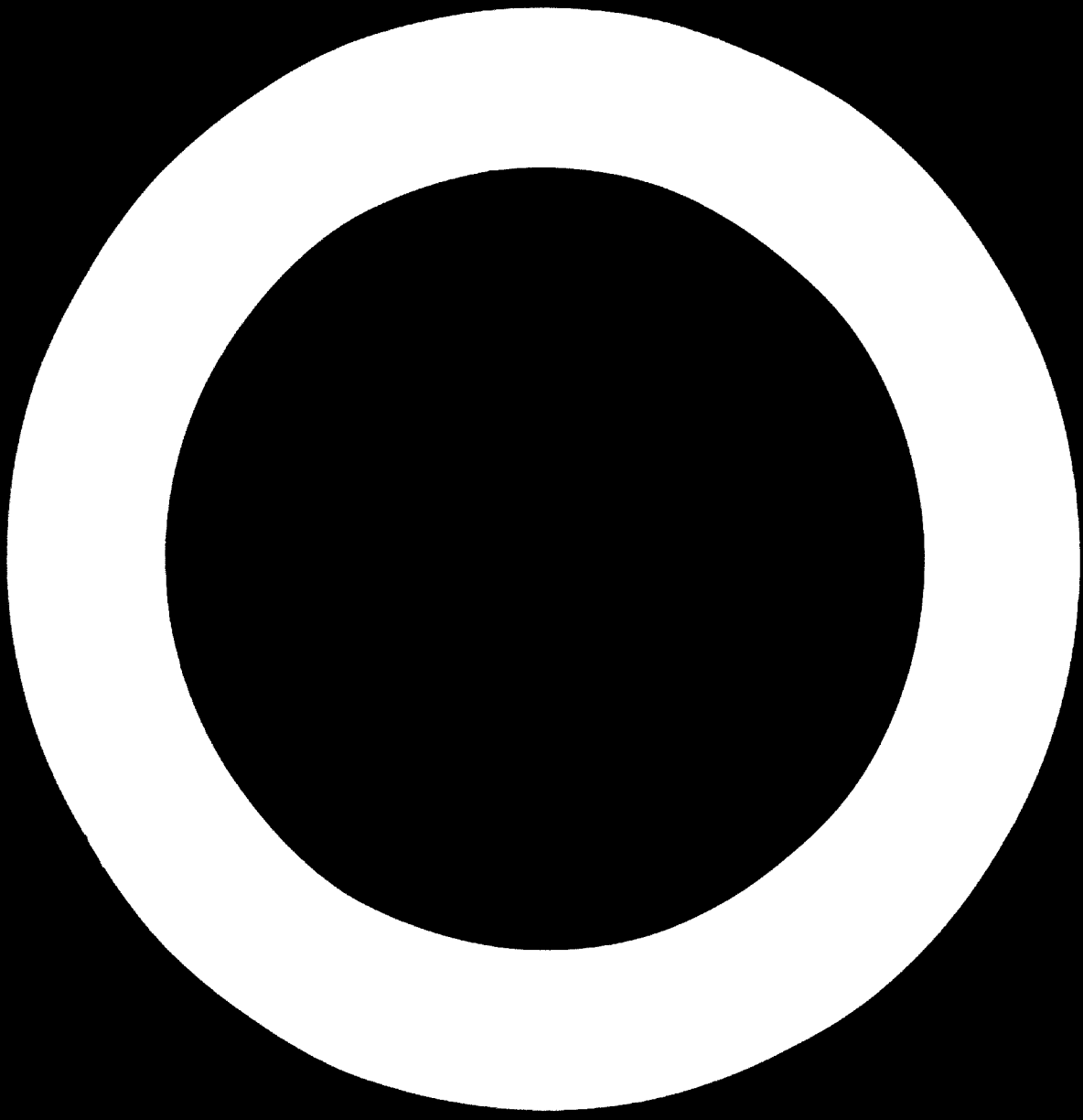

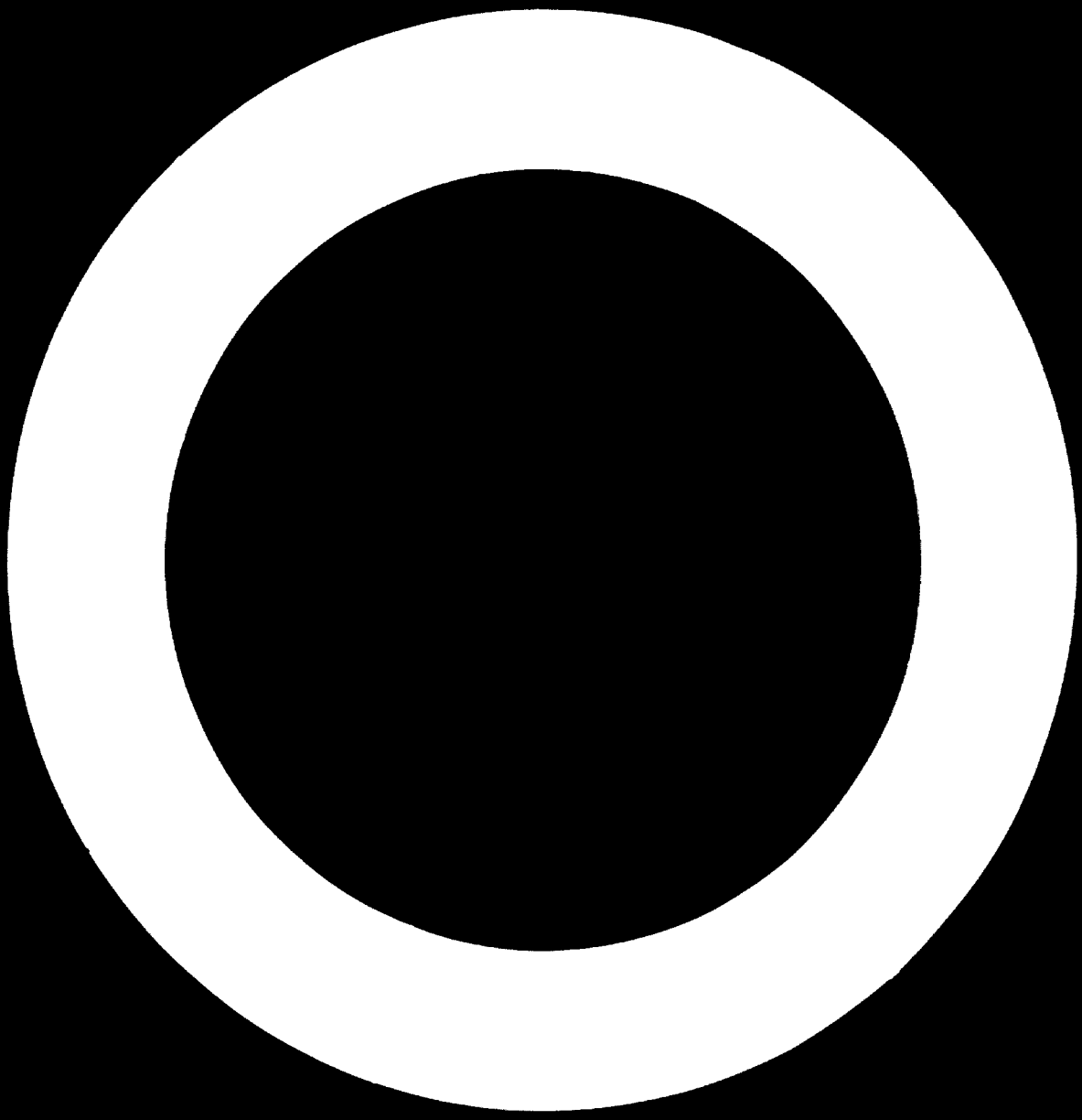

United Nations Development Programme

LIMITATION OF AIR POLLUTION BY INTERNAL COMBUSTION ENGINES

IN [illegible]

POLAND

Technical report: Measurement and control of air pollution from motor vehicles

Prepared for the Government of Poland
by the United Nations Industrial Development Organization,
executing agency for the United Nations Development Programme

Based on the work of R. P. Murphy, expert in the organization of emission control stations, instruments and pollution control

United Nations Industrial Development Organization
Vienna, 1975

Explanatory notes

Reference to "tons" indicates metric tons, unless otherwise stated.

Reference to "dollars" ($) indicates United States dollars, unless otherwise stated.

Use of a hyphen (-) between dates representing years signifies the full period involved, including the beginning and end years, e.g. 1971-1973.

A full stop (.) is used to indicate decimals.

A comma (,) is used to distinguish thousands and millions.

The following abbreviations are used in this report:

CKD	completely knocked down
ECE	Economic Commission for Europe
WHO	World Health Organization

The Polish monetary unit is the zloty (Zl). During the period of the project its value in relation to the United States dollar was $1 = Zl 19.92.

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SUMMARY

This report on the project "Limitation of Air Pollution by Internal Combustion Engines" (IS/POL/74/005) examines the actual and potential pollution problems arising from motor vehicle emissions in Poland and makes recommendations on legislation, organization, measurement and control considered necessary to solve existing problems or to prevent them from worsening.

It is concluded that an air pollution problem from motor vehicles already exists in the central city areas of major Polish cities such as Warsaw and Cracow. With the rapid increase in production of passenger cars, 24% per annum over the past four years, the problem can be expected to worsen rapidly unless control measures are begun now. It is recommended that steps be taken:

To provide the necessary legal base for action

To establish an organization with the authority and responsibility to control motor vehicle emissions

To introduce interim control measures

To determine or to confirm the actual concentrations of motor vehicle related pollutants in the ambient air

To determine the actual emissions that are occurring from motor vehicles in Poland and to relate these to the air quality

To prepare a control programme which will prevent any further worsening of air pollution levels arising from motor vehicles and ultimately bring about an improvement

To implement these steps detailed recommendations have been made on each of the above matters. A proposal is made for the installation of sophisticated ambient air pollution monitoring equipment to determine accurately the air pollution levels in major Polish cities.

It has been estimated that the cost for the necessary emission measuring equipment will be $84,550 and for the air pollution monitoring equipment $85,650, making a total of $170,200. Much of the equipment required could only be obtained from Western Europe, the United States or Japan. Data on the equipment, its cost and possible suppliers are included in the report.

Finally, the report recommends the establishment of a project steering committee under the authority of the Ministry of Environment, Ministry of Machine Industry and Ministry of Transport. The proposed committee would comprise representatives of the three ministries and also the research institutes together

With a representative [illegible]. The task would be to prepare a study on the measurement of emissions and air quality and to make a survey of a representative sample of, say, [illegible] in-service vehicles to establish the emissions that are occurring. From the data on actual air quality and emissions a model should be constructed relating these two variables and then a control programme developed, taking into account the projected increase in motor vehicles.

INTRODUCTION

This technical report deals with the development of organization, legislation and methods for the measurement and control of air pollution arising from the operation of motor vehicles in Poland. The study was carried out from 14 November to 9 December 1975 under the technical assistance programme of UNIDO and at the request of the Polish Government. This is the first instance where air pollution from motor vehicles in Poland has been examined by a UNIDO expert.

The project "Limitation of Air Pollution by Internal Combustion Engines" (US/POL/74/009) had its origin in a request from the UNIDO Geneva office dated 24 April 1974 and was given initial approval on 7 June 1974. Subsequently there were four amendments mainly to take account of increased costs in the rates for experts and also for equipment. The work plan was also extended so as to require that special attention be directed towards the legal situation and the selection of monitoring equipment. Approval to the amended project was finally given on 17 October 1975 at a budgeted cost of $76,500.

The emission of exhaust fumes from motor vehicles is receiving increasing attention from air pollution control authorities throughout the world. The high concentrations of carbon monoxide in central city streets, the onset of photochemical smog in cities such as Los Angeles, Tokyo and Sydney, and smoke or odorous emissions are examples of air pollution to which motor vehicles are major contributors. Potentially harmful emissions of lead compounds and oxides of nitrogen also occur from motor vehicles.

The motor vehicle manufacturing industry in Poland is developing rapidly, particularly with regard to the production of passenger cars. The total annual production of vehicles, excluding motor cycles, reached 288,000 in 1975 of which 200,000 were passenger cars and their derivatives. Passenger car production has increased at an annual rate of 24% since 1970 which means a doubling of output every 3.25 years. The national vehicle registration totals four million, of which one million are passenger cars, two million motor cycles and the remainder trucks, buses and tractors. The present high rate of increase in passenger car production implies that Poland is about to enter an era of the private motor car and could therefore expect the problems of air pollution and noise to worsen unless steps are taken to control them.

Terms of reference

The terms of reference for the study as set down in the job description and project data sheet were as follows:

"In close co-operation with the Government authorities the expert will be expected to:

1. Make a detailed assessment of the extent of air pollution stemming from internal combustion engine emission, taking into account the prevailing meteorological conditions;

2. Review existing legislation pertaining to air pollution and make recommendations on the form of legislation which will be required for controlling automotive emission;

3. Assess the type of equipment which will be needed for proper monitoring of air pollution and prepare the technical specifications and likely cost of this equipment;

4. Assist, if requested, in the preparation of a training programme under two UNIDO fellowships, and advise on suitable centres for training the two fellows;

5. Submit an interim report to include the findings of the expert, the details of equipment required, as mentioned under item 3 above, and the proposed training programme for the two fellows.

"The expert will pay special attention to assessing the over-all situation including the present legal situation, etc. He will furthermore, particularly assist in selecting the most suitable equipment and finalize the relevant technical specifications. If requested he shall also assist in preparing the training programme for the two fellows."

I. FINDINGS

A. Motor vehicle emission legislation

There is no national legislation in Poland dealing with motor vehicle emissions other than standards limiting the lead content of petrol. Legislation generally is enacted by the Government, the voivodships (counties) having limited administrative powers delegated from the central level. With regard to motor vehicles all technical directives emanate from the Government and therefore are uniform throughout the country.

The general controls for motor vehicles are based on the concepts that an article must comply with any national standards that may be prescribed in relation to it by the Government and that the owner or driver of a motor vehicle must comply with any requirement set down in the Road Code.

Secondary standards can be established by a minister so as to apply to activities carried out within his ministry. These standards are termed "branch standards". They do not have the force of law and therefore are not binding on all citizens. However, they must be complied with by those organizations in the ministry or ministries concerned, failure to do so resulting in censure of the manager or private owner supplying the industries, and in imposition of an administrative penalty of up to Zl 5,000.

The Ministry of Machine Industry and the Ministry of Transport have announced that branch standards dealing with motor vehicle emissions will come into force on 1 January 1976. These standards will apply to all new models of motor vehicles or motor vehicle engines manufactured after that date. With regard to vehicles with spark ignition engines the standards will be identical with the Rule 15 (1969) of the Economic Commission for Europe (ECE) with type 1, 2 and 3 tests, whilst for compression ignition engines ECE Rule 24 has been adopted.

The prescription of branch standards means that all new model vehicles weighing more than 0.4 tons and fitted with a spark ignition engine will have to be so designed that emissions of carbon monoxide and hydrocarbons are limited to the values set down in the standards. Limits have been set for carbon monoxide when the vehicle is idling and also for carbon monoxide and hydrocarbons when tested on a chassis dynamometer to a cycle intended to simulate operation on the road. In addition, the standards require that new vehicles be fitted with a positive crankcase ventilation valve to prevent the emission of blow-by gases from the crankcase.

The low compression ignition engines, that is diesel engines, must be so designed that when the engine is tested on an engine dynamometer at full load and at a range of speeds ranging up to that for maximum power output, the emissions of smoke comply with the limits for the light absorption coefficient set down in the standard.

E. Ambient motor vehicle air pollution monitoring

The data on motor vehicle related pollution in Poland are limited. In Warsaw and Krakow surveys employing random sampling and wet methods of chemical analysis have been carried out by the Research Institute on Environmental Development and the Technical University of Warsaw. In addition, the Environmental Pollution Management Centre and the Sanitary Epidemiological Station in Katowice have carried out random and continuous 24-hour manual measurements of carbon monoxide, oxides of nitrogen, carcinogenic hydrocarbons and lead in various areas of the Katowice voivodship since 1970. These pollutants are usually produced by motor vehicles; however, in the Katowice region the major sources are heavy industry and power stations.

The environment authorities in Poland have been concentrating on the measurement of air pollution from stationary sources. It is considered that it is in this area where urgent action is required. The air pollution from motor vehicles will become a problem only in the future and therefore the solution of it should be given a lesser priority. The gross levels of dust fall, suspended dust and sulphur dioxide in many of the industrial regions of Poland support this view. However, an examination of the limited Polish data on pollution from motor vehicles together with the expert's observations indicate that the levels of carbon monoxide, suspended smoke particles and odorous mercaptan-type compounds are unacceptably high in central city areas. Action towards control of these pollutants should be started now.

No measurements of ozone or oxidant concentrations in the atmosphere have been made in Poland yet. It has, therefore, been possible to estimate only the potential of photochemical pollution on the basis of meteorological conditions and emissions of primary pollutants in those cities where dispersion is known to be restricted.

The organizations visited and the information obtained on ambient air pollution levels and related matters are set out below under separate headings.

Research Institute on Environmental Development

This Institute was established in 197[illegible] and combined the activities of four former institutes so as to develop a multi-disciplinary approach to environmental problems associated with planning and pollution. The total staff amounts to 1,25[illegible] scientific, technical and administrative employees of which over 2[illegible] hold degrees in 30 different disciplines. The Institute is established under the Ministry of Land Resources Management and Environmental Protection and its main responsibility is to prepare basic scientific and technological data for the ministry.

In Poland, monitoring stations for air pollution are operated by branches of the Division of Air Protection or, more frequently, by the voivodships. The Institute establishes the measuring methods to be used or supervises the monitoring to ensure accuracy. Detailed measurements of pollution from motor vehicles had not been commenced and only limited survey data existed. A national survey on emissions had indicated that 70% of all air pollution was caused by industry, 20% by domestic heating and 10% by motor vehicles. Yearly emissions were approximately as follows:

	Million tons
Sulphur dioxide	4
Solid particles	4
Nitrogen oxides	2
Carbon monoxide	2

A Clean Air Act, passed in April 1966, provides the legal basis for the control of air pollution in Poland. National air quality standards for specific pollutants should be established before the control of air pollution could start. National standards on allowed concentrations in ambient air for 16 air pollutants and for dust fall are shown in table 1. It will be noted that for protected areas such as national parks and health resorts, the established standards for allowed concentration of carbon monoxide are 0.5 mg/m^3 for 24 hours and 3.0 mg/m^3 for 20 minutes. No standards, however, have been prescribed for protected areas such as residential areas in cities. That is one of the reasons why there is no control of pollution caused by carbon monoxide in protected areas. For other pollutants emitted by car engines (nitrogen oxides, hydrocarbons, lead and suspended dust) air quality standards have been established for protected areas. However, with the exception of suspended dust, the pollutants are not being measured continuously by the Institute.

Polish ambient air quality standards[a]
(mg/m^3)

Substance	Sampling period in specially protected areas		Sampling period in protected areas	
	24 hours	20 minutes	24 hours	20 minutes
SO_2	[illegible]	0.225	0.35	0.9
[illegible]	[illegible]	0.15	0.1	0.3
[illegible]	[illegible]	0.15	0.2	0.6
[illegible]	[illegible]	[illegible]	[illegible]	0.06
[illegible]	[illegible]	3.0	-	-
Petroleum hydrocarbons	[illegible]	2.5	-	-
Suspended dust, non-toxic (< 4 µm)	[illegible]	[illegible]	[illegible]	0.6
Carbon disulphide (CS_2)	-	-	0.015	0.045
Arsenic	[illegible]	[illegible]	0.003	0.01
Benzene	[illegible]	[illegible]	0.3	1.0
Chlorine	[illegible]	[illegible]	[illegible]	0.1
Hydrogen chloride	[illegible]	[illegible]	[illegible]	0.2
Phenol	[illegible]	[illegible]	[illegible]	0.02
Fluorine and compounds	[illegible]	[illegible]	0.01	0.03
Formaldehyde	[illegible]	[illegible]	[illegible]	0.05
Lead and compounds	[illegible]	-	[illegible]	-
Dust fall	400 tons/km^2/year (max. 6.5 tons/km^2/month)		250 tons/km^2/year	

a/ According to orders of the Council of Ministers on allowed concentrations in ambient air, dated 13 September 1966, 15 May and 27 May 1972.

During 1973, suspended dust near Warsaw main roads averaged from 0.4 g to 0.75 mg/m^3, for 20 minute samples. Dust fall in Warsaw ranged from a maximum of 546 tons/km^2/year to a minimum of 66 tons/km^2/year. Typical values for a Warsaw street were 300 tons/km^2/year for dust fall and 0.5 to 0.6 mg/m^3 of suspended dust for a 20 minute sample.

It was stated that the function of the Ministry of Land Resources Management and Environment Protection was to supervise and co-ordinate, but not to carry out, detailed control action. Every ministry was expected to take any necessary steps to meet the national standards on being advised by the Environment Ministry that it was the cause of the standards being exceeded. The

Ministry of Health had an advisory function and had published its recommendations on "no effect" levels for 170 pollutants. Voivodship authorities, although their administrative powers are limited, implemented the law for smaller plants.

It is clear that the environment authorities in Poland have neither adequate legal authority nor technical facilities to measure or control motor vehicle pollution. Furthermore, they seem hesitant to assume any responsibility for the tasks with the inadequate authority or inadequate facilities.

Division of Computer Services

Discussions were held with the management on the methods for processing the data obtained from continuous air and water pollution monitors. The input data from continuous monitors at field stations will be recorded on a magnetic tape (compact casette ECMA 34) and on strip charts. The tapes will be collected monthly and brought to the computer centre for processing on a simple computer developed in Poland. This procedure is similar to the one that is used in Australia, except that in Australia a punched paper tape is used instead of a magnetic tape. Specifications of the data acquisition and storage systems used in Australia together with data on the equipment purchased and its costs were made available to the division. (The cost of a data acquisition and storage system for one field station in Australia capable of handling 13 inputs was approximately $6,300 at June 1975 prices.)

Environmental Pollution Abatement Centre - Katowice

The Centre was established in March 1973 to make an in-depth study of environmental pollution in the voivodship of Katowice, which is the most heavily industrialised and densely populated region of Poland. The region suffers from severe pollution of air, water and land. The study project is being carried out jointly by the European Office of the World Health Organization (WHO) and the Centre. The project is being supported financially by UNDP to a value of $1,455,000 and by the Polish Government with Zl 118,876,000. The UNDP funds are being used to pay for the experts, to provide fellowships for 392 man-months and to purchase sophisticated analytical and monitoring equipment. On this basis the Centre has acquired and is still acquiring continuous monitors for carbon monoxide, oxides on nitrogen, hydrocarbons, oxidants, sulphur compounds and suspended dust.

The emissions from motor vehicles form only a minor proportion of the total emissions in the area. An extract from an emission survey carried out as part of the project is shown below in table 2. The survey demonstrates that, although the industry is the major source of pollution, emissions from motor vehicles form a significant, rapidly increasing proportion of the total emissions of carbon monoxide, hydrocarbons and oxides of nitrogen.

Table 2. Emissions of air pollutants in Katowice voivodship, 1972 (Thousand tons/year)

Pollution source	Dust	Pb	SO_x	NO_x	CO	HC
Industry	791.	2.2	479	121	398	109
Motor vehicles	.9	.2	3.9	17..	97	18
Steam locomotives	1 .?	-	2. .?	1.4	43	10
Domestic heating	22.4	-	53.?	4.1	111	22
Other municipal sources	4.8	-	6.5	1.5	6	2
Total	840.1	2.4	562.4	145.1	655	161

The centre will have the only sophisticated equipment for monitoring motor vehicle related pollutants in Poland. It will give valuable information on the levels of pollution that exist in the area. In this region the control of emissions from stationary sources have priority and will dominate the results unless some sampling points are chosen with the aim of monitoring motor vehicle pollution.

Warsaw Technical University

The first studies on motor vehicle pollution in Poland were carried out by Wiesław Skorupski of the Warsaw Technical University, commencing in 1968. Concentrations of carbon monoxide, nitrogen oxides, carbon dioxide, and suspended dust in the ambient air were measured in central city areas of Warsaw and Cracow. Dust fall in a number of heavy traffic areas was also measured as well as the rate of traffic flow at a number of major intersections in Warsaw.

The measurements of gaseous pollutants have been carried out by first absorbing them in reagents using fritted glass bubblers and then analysing them by wet chemical methods. Samples of suspended dust have been obtained with high volume samplers. Samples have been collected for 24-minute periods throughout each day that has been selected for sampling and peak and average values have been determined for each pollutant. The analytical procedure used for carbon monoxide has been compared with results obtained from an infra-red spectrophotometer and excellent correlations have been obtained.

The results of Skorupski's work show that high concentrations of carbon monoxide, oxides of nitrogen and suspended dust occur at major intersections in central city areas. At the busiest intersection in Warsaw (Marszałkowska and Al. Jerozolimskie), the traffic flow was 29,[illegible] cars per day with a peak of 5,000 cars per hour. Concentrations of carbon monoxide reached peak values of [illegible] mg/m^3 in 1975, and the annual average values of Marszałkowska increased from 2.32 mg/m^3 in 1968 to 9.91 mg/m^3 in 1974. Annual average of suspended dust concentrations increased from 0.37 to 0.68 mg/m^3 during the same period (see table 3).

Table 3. Air pollution levels from motor vehicles in Warsaw

Measuring point	1968	1969	1970	1971	1972	1973	1974
	CO (mg/m^3)						
Marszałkowska street	2.32	2.71	3.00	3.99	4.80	8.20	9.91
Noakowskiego street	0.48	0.51	0.52	0.60	2.36	6.12	7.19
Dziedziniec Park	0.23	0.26	0.24	0.39	0.78	2.11	2.00
	N_2O_5 (mg/m^3)						
Marszałkowska street	0.27	0.39	0.43	0.46	0.53	0.81	0.80
Noakowskiego street	0.29	0.30	0.41	0.52	0.60	0.78	0.69
Dziedziniec Park	0.19	0.20	0.21	0.26	0.39	0.49	0.43
	Suspended dust (mg/m^3)						
Marszałkowska street	0.37	0.34	0.45.	0.59	0.64	0.72	0.68
Noakowskiego street	0.32	0.31	0.32	0.58	0.60	0.68	0.64
Dziedziniec Park	0.19	0.20	0.25	0.29	0.32	0.34	0.29
	Dust fall (tons/km^2/month)						
Marszałkowska street	280	295	299	264	266	293	287
Noakowskiego street	273	269	280	271	273	282	266
Dziedziniec Park	240	236	240	227	240	246	238

The above values are similar to those obtained elsewhere in the world in the cities with heavy traffic. On many days, the levels of carbon monoxide and suspended dust exceed the long-term goals established by WHO. This fact indicates the necessity of motor vehicle emissions control. Sophisticated monitoring equipment for continuous monitoring of carbon monoxide and suspended dust should be installed in order to confirm the validity of the data already obtained and to indicate the effectiveness of any control measures that might be introduced. Recommendations on the number and type of such equipment are made in annexes I and II of this report.

In Cracow the concentrations of carbon monoxide and suspended dust were higher than in Warsaw and they occurred with greater frequency. It is estimated that other large Polish cities such as Łódź, Wrocław, Poznań, Gdańsk and Lublin have substantial concentrations of air pollutants in central city areas, but no data on motor vehicle pollution levels exist to confirm this. However, the vehicle density and the prevailing meteorological conditions are suitable for the build-up of pollution levels in central city areas, especially in Cracow, Lublin and Gdańsk.

Meteorological considerations

Discussions on the meteorological conditions that exist in Poland were held at the Institute of Environmental Development. Broadly the synoptic pattern over Poland results in geostrophic winds from the west and a regular succession of high and low pressure systems at quite high frequency. The frequency of low pressure systems is 60 to 70% in summer time and 40% in winter time. Considerable variations in wind intensity and direction, both horizontally and vertically, occur at low pressure conditions, causing difficulty in forecasting.

During high pressure conditions, particularly in winter time, dispersion of pollutants is poor. Such systems can persist over Poland for as much as 10 days, although, in one location, they usually persist only for 4 to 5 days. In Cracow where special topographical conditions also exist, local steep temperature inversions have been observed for 250 days per year. This city is, therefore, particularly prone to a build-up of air pollution. Similarly, special topographical and meteorological conditions exist in Lublin and Gdańsk which could cause a build-up of air pollution because of poor dispersion. In the Katowice region meteorological conditions are dominated by the normal synoptic pattern but nonetheless pollution is at a sufficiently high level to produce a 20 to 30% loss in total annual solar radiation. Similarly, in Warsaw a loss of 15% in annual solar radiation has been recorded.

Photochemical pollution potential

The potential for photochemical pollution was examined for a number of areas in Poland. It would seem that the necessary meteorological conditions of a stationary, blocking high pressure system, sufficient sunshine and low speed early morning wind do occur in summer in a number of cities including Cracow, Lublin, Gdańsk and Warsaw. The situation in Gdańsk is particularly complex and it would be impossible to predict the potential. Detailed data on the frequency of the required meteorological conditions in the above cities are being extracted from weather records but were not available at the time of writing this report.

Although, at present, it seems unlikely that the necessary quantities of precursor emissions (i.e. hydrocarbons and oxides of nitrogen) are emitted in Polish cities for high oxidant levels to occur, the growth in motor vehicle numbers and the associated petroleum refining industry together with the meteorological conditions would provide the required ingredients for it to occur at some future time. The continuous monitoring of ozone, say, 5 to 10 km down wind from major source areas should, therefore, be commenced as soon as possible so that crash control programmes can be avoided. The use of monitoring instruments could be supplemented with the use of sensitive plants, such as white petunias or morning glories, and rubber strips as oxidant indicators.

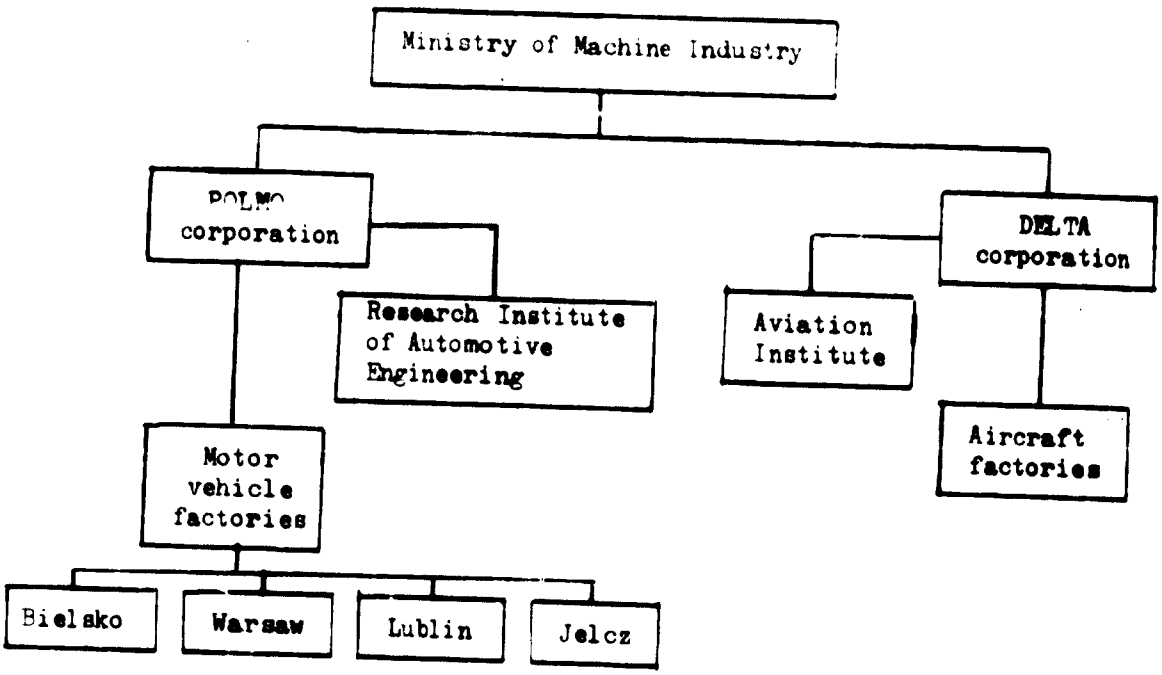
Odorous emissions from motor vehicles

It was observed on many occasions whilst in Poland that emissions from motor vehicles were particularly odorous. This was most obvious from vehicles with two-stroke engines but also from diesel and four-stroke petrol engined vehicles. An examination of the petrol in use showed it to be very odorous indicating that mercaptans and other complex sulphur compounds were not being removed during refining. Automotive distillate fuels also had a somewhat higher sulphur content (0.6%) than in many other countries. The removal of the odorous compounds from the petrol by hydrotreating followed by M.E.A., A.D.I.P. or caustic treating would greatly reduce the objectionable emissions that are at present occurring. Further hydrodesulphurization of the automotive distillate would also have beneficial effects on odorous emissions but this would not be as significant as the cleaning of the petrol. It was stated that a new refinery was being constructed at Gdańsk and that it will be equipped with secondary

refining units. Other refineries were also being equipped with reforming, alkalation and other secondary units and it would seem that this would provide the opportunity to install petrol deodourizing units as mentioned above. Such action would have an insignificant effect on the selling price of petrol.

Development of motor vehicle emission controls

The manufacture of motor vehicles in Poland is the responsibility of the Ministry of Machine Industry through its manufacturing corporation POLMO. The organization is, broadly, as shown in the following chart.



At the beginning of this mission a visit was made to the Department of Research and Development of the Ministry of Machine Industry and discussions held with the Deputy Director. It was indicated that the Ministry wished to develop knowledge on the control of emissions from motor vehicles so that the necessary steps could be taken to prevent a problem from developing in Poland in the way that had occurred elsewhere. The impression was formed that the export of vehicles was also a factor in the interest shown. Nonetheless, events were to show that more real interest in the subject was shown by the vehicle manufacturers than any other organization with which contact was made. Contact between the Ministry for Environment and the Ministry of Machine Industry was said to be weak but this was due to the newness of the former Ministry and this situation was expected to change with time.

The organizations visited and the information obtained on developments in motor vehicle emission control are discussed below under separate headings.

Research Institute of Automotive Engineering (PIMot)

The activities of this Institute include development of the design and the solving of theoretical and practical problems associated with motor vehicle manufacture. It, therefore, has the primary responsibility for developing emission control methods for Polish motor vehicles. Much of the expert's time, whilst in Poland, was spent at this Institute or at associated organizations. The counterpart, Mr. Pawel [illegible], an engineer of this Institute and also a UNIDO Fellow, gave invaluable assistance throughout the visit.

There will be a major expansion in the Institute's facilities which are already very substantial. At the present time, there are approximately 15 engine dynamometer bays and one chassis dynamometer equipped with instruments for testing vehicle emissions in accordance with the ECE 1969 procedure at the Warsaw site. A constant volume sampler and a chemiluminescent oxides of nitrogen analyser, provided by UNIDO, will be added to this facility and extend its capability. A new facility which will include 15 further engine dynamometer bays and a further chassis dynamometer together with offices and a large clear span area for rig testing, workshops and vehicle storage will be erected.

After examination of the design of the proposed chassis dynamometer facility the expert advised to extend its area so that vehicles could be conditioned for, say, 10 hours at temperatures between 15° and 30°C and tested at temperatures between 24° and 30°C so as to be able to comply with requirements in the United States test procedures. Details of facilities in Australia would be made available, if practicable, to assist in finalizing the design.

The Institute has a total staff of 1,[illegible] employees at a number of locations in Poland. The Engine Department has a staff of 80 engineers whilst the Combustion Division of this Department has a staff of 15 engineers. Expertise has been developed in the emission testing of a variety of vehicles of both Polish and foreign manufacture and also in the techniques that are required to meet the ECE standard. Research work has also been conducted into methods of reducing emissions well below those required to meet the ECE standards. This work is to be extended when improved equipment for oxides of nitrogen analysis is obtained from UNIDO.

Bielsko Factory

The Research and Development Division's facilities at Bielsko were visited and discussions held with the Director, and a number of staff. This Division is concerned with controlling the quality of vehicles produced by the organization and in solving the day to day technical problems experienced in manufacturing.

The Bielsko factory commenced the production of the mini Polski Fiat 126 in 1973 and output is expected to reach [illegible] in 1979 and 200,000 in 1978. This vehicle is intended to become the "people's car". It is powered by a [illegible] cm³, twin-cylinder, air-cooled, four-stroke petrol engine of 23 hp output and seats four passengers. It sells for Zl [illegible]. The Bielsko factories also produce the Syrena sedan. This is a small sedan powered by a three-cylinder two-stroke engine of 40 hp. The production is about 4,000 per annum and will not increase. No further design development is to occur with this vehicle and it is planned to cease its production at some future unspecified date before large scale retooling is necessary. A date of 1981 was suggested with some qualification. The Syrena sells for Zl 74,000 and is, therefore, a competitor to the Fiat 126. The extent of public demand for its continued supply will be an important factor as to the date of cessation of production. From an air pollution view point, the sooner the better, as two-stroke-engined vehicles are notorious for heavy emissions of odorous hydrocarbon compounds and examination of test data showed the Syrena to be no exception.

The Bielsko factories also produce about 1,000 Fiat 127 vehicles from CKD packages imported from Italy. This is a small front-wheel-drive sedan powered by a 46 hp, four-stroke engine of 903 cm³ capacity. There is no intention of increasing the production of these vehicles at present. However, they have very good performance and road holding features and the writer believes there will be an increasing demand for them.

The Division is equipped with modern facilities for the emission testing of vehicles to the ECE standards. In discussion with the testing engineers it became apparent that they were very competent and that the test results could be accepted with considerable confidence. Tests were conducted on randomly selected vehicles in the ratio of one test vehicle to 2,000 produced. Examination of typical test results on the Fiat 126 showed that it was complying with the ECE (1975) standards which are slightly more stringent than the ECE (1969) standards. The demand of the export market is for compliance with the ECE (1975) production vehicle testing.

Fiat has a responsibility under the [illegible] agreement [illegible] improvements for Polish Fiats [illegible] by FSO until 198[illegible]. The factory collaborates with [illegible] and also with the [illegible] manufacturers to achieve the uniformity of [illegible] gases. Such collaboration should be extended [illegible] are carrying out emission tests.

[illegible]

This Institute is primarily concerned with [illegible] research, [illegible] Combustion Processes Laboratory of the Engine [illegible] has carried out [illegible] fundamental design work for the manufacturers of diesel engines aimed at reducing emissions of oxides of nitrogen, hydrocarbons, carbon monoxide and smoke. The Institute is an agency of the Ministry of Machine Industry. Discussions were held with the Head of the laboratory and one senior engineer.

At the laboratory an engine dynamometer was installed and a one-cylinder research diesel engine (9 x [illegible] mm) was running to examine the effectiveness of a catalyst device employing iron pellets, at the time of the visit. A Beckman sampling and analysis system employing flame ionization detection for hydrocarbons, chemiluminescence for oxides of nitrogen and infra-red spectrophotometry for carbon monoxide was installed to analyse the exhaust gases. A Bosch smoke meter was installed for smoke measurements.

Research work has been carried out on this apparatus to determine the influence of combustion chamber design on the emission of pollutants. A combustion chamber formed as a cavity in the piston was developed which made major reductions in emissions. The cavity, termed the "squish-lip" type, caused a high turbulence level and resulted in combustion under rich conditions followed by lean combustion as the gases passed from the cavity into the main combustion chamber of the cylinder. Although the design seems promising, it has not been adopted by the manufacturers because they doubt its durability. A steel insert to form the combustion chamber is being considered.

Research work has also been carried out into the influence of retarded injection on emissions. This technique is known to reduce emissions of oxides of nitrogen but in some cases carbon monoxide and hydrocarbons can be increased. The work showed that some retardation was practicable. Power loss would not be unacceptable and could be compensated for by turbo charging.

The Institute has the necessary facilities and skilled staff to carry out other emission control studies on diesel engines. However, it would need a particle type smoke meter to complete its test facilities in order to take part in any study directed towards the development of national standards for the control of both smoke and gaseous emissions from diesels.

Transport Institute

Broadly, the Institute has a responsibility to test and certify prototypes of new model vehicles for their compliance with national or branch standards and to participate in the development of standards and test procedures for the inspection of in-service vehicles by the voivodship inspection stations.

Up to this time, much of the Institute's efforts have been directed towards the control of noise from new vehicles and national standards have been established for allowable levels, both internally and externally. Efforts are being made to introduce a standard for noise emitted from in-service vehicles. A draft branch standard has been prepared but has not yet been implemented. The 150 voivodship inspection stations should be equipped with appropriate test equipment and additional stations should be constructed before implementation could commence.

In relation to inspection of in-service vehicles the Institute and Ministry establish the standards and test procedures in colaboration with other relevant organizations and then the voivodship inspection stations, operating under authority delegated to the voivodships, carry out the inspections and issue certificates of road worthiness. These inspections are mainly directed towards safety aspects and at this time only subjective judgements are made of emissions of noise and smoke from the exhaust systems. Authority exists in the Road Code to permit rejection of vehicles which are "excessively" noisy, but it would appear to be only applied in cases of gross noise from in-service vehicles. The Institute trains inspectors and mechanics and checks and calibrates testing equipment.

With regard to the emission of air pollutants a start has been made on developing controls but the lack of a legal base has created an impediment. It is intended to ammend the Road Code so that it becomes an offence to emit excessive quantities of air pollutants and when this is done to prepare a ministerial instruction limiting the emission of pollutants from in-service vehicles

undergoing re-registration inspection. The first regulation is expected to limit carbon monoxide emission to 4.5% at idle. However, as with Poland, the inspection stations would first have to be equipped with test equipment before implementation could commence.

With regard to new vehicles, a branch standard for emissions from diesel vehicles will come into force on January 1st. It was stated, however, that the Institute has neither facilities nor staff to test such vehicles for certification. For spark ignition engines the preparation of a branch standard for new vehicles is nearing completion and the Institute will be issuing certificates of compliance for new models that will be tested in it's test facility. The procedure is to issue a certificate of compliance to the manufacturer and to advise the inspection stations when a new model complies with the requirements. The Institute also has the right to test production vehicles but does not expect to be doing so because of lack of facilities.

An inspection was made of the analytical laboratories and emission test facilities at the Institute. The analytical laboratories were well equipped with sophisticated analytical instruments which would permit a wide variety of analyses to be performed. If anything, the laboratories appeared to be over-equipped in relation to the available staff. With regard to the emission test facilities, a chassis dynamometer and exhaust gas analysis instruments were installed to permit testing to the ECE cycle. N_x was determined by wet chemical methods (modified Salzmann). Calibration of the infra-red hydrocarbon analyser was carried out with propane standard gas, appropriately diluted, employing a factor to relate it to hexane. This procedure is allowable under the standard but inter-organization comparisons seem essential because hexane is used at Bielsko and at the Institute of Automotive Engineering.

An engine dynamometer with a 200 hp Leyland type diesel engine on the test bed was also inspected. This apparatus was being used to investigate emissions of smoke, hydrocarbons and oxides of nitrogen from the engine. A Hartridge Mark 3 smoke meter was being used to measure smoke; a F.I.D. instrument for hydrocarbons and grab samples followed by wet chemical analysis for the other pollutants. It would appear that expertise in testing procedures was being developed at this stage and that further experience had to be gained before certification testing could be commenced.

The Institute had made proposals for the erection of three further chassis dynamometers, two for testing motor cars and their derivatives and one for large diesel vehicles. A decision on this proposal is yet to be finalized.

Although there is a need for increased testing facilities in Poland, particularly among those organizations that will be supervising the manufacturers, nevertheless, the facilities already in existence at this Institute could be used with much greater frequency. Even without any change in the existing facilities, random testing of production spark ignition vehicles and diesel engines could be commenced to establish compliance with the existing branch standard in force and the proposed branch standard for spark ignition engines. For certification testing, only minor extension and improvement of the facilities seems necessary to establish compliance with existing and proposed branch standards for new vehicles. As these standards become more stringent, chemiluminescent modes of nitrogen analysers and F.I.D. hydrocarbon analysers will be required. Furthermore, a under-cover, heated vehicle storage is also necessary. Ultimately, constant volume samplers may also be required but a change in the test procedure would first have to occur.

Ministry of Transport

A brief discussion was held with the Director of the Department of Road Transport of the Ministry of Transport. From this discussion the impression was formed that the Ministry of Transport would not hasten to adopt the more stringent P.R.L. standard as a branch standard or a national standard unless pressures were imposed by the Ministry of Environment or the Ministry of Health requiring it to do so.

Voivodship Inspection Station - North Warsaw

A visit was made to the North Warsaw Inspection Station to observe the procedures for re-registrations. This station, one of four in Warsaw, inspected 34,000 vehicles in 1974. The number of inspections is increasing by 20% per annum. The station is equipped with two lanes, one for light duty and one for heavy duty vehicles. The inspection includes the thorough testing of brakes, on a brake tester, lights, steering etc. The owner of a vehicle that fails the test is given a notice informing him of the matters that require attention. Minor adjustments and repairs are carried out by staff of the Inspection Station but major work is performed by repair workshops.

Equipment, manufactured by Clayton, to diagnose and tune the electrical and the fuel systems of vehicles is installed at the Inspection Station. A complete diagnosis and tuning is carried out for a fee of Zl 208. The

diagnostic equipment in [illegible] the ratio of the vehicle. [illegible] earlier but it was discarded because it's design did not maintain calibration.

There is little doubt that the inspection system in use in Poland could be extended to include smoke and invisible exhaust gas measurements. However, the stations should be equipped with reliable measuring equipment and the staff should be trained in measurement and adjustment before the meeting of emission standards could become obligatory. Furthermore, legislation and the prescription of standards should be introduced. It is considered that the introduction of such an extended inspection system could first be piloted. A way this could be done would be to require all state-owned vehicles in Warsaw meet a standard of 4.5% CO emission at idle, prohibiting any visible emissions (excluding water vapour) after 15 seconds of operation on the road.

After experience is gained and legislation enacted, the extended inspection system could be introduced progressively to all state and private vehicles in Poland. In relation to privately-owned vehicles the present system, requiring a vehicle to be inspected three years after its purchase, then again, in two years, and then every year, would be inadequate for pollution control, even though satisfactory from the safety view point. For a real improvement in emissions, every new vehicle should be inspected prior to its first registration and at least every year thereafter.

Studies have shown that the introduction of a system of inspection and tuning of all vehicles could be expected to reduce the total emissions of carbon monoxide by about 1 %, and hydrocarbons by about 1%. This improvement must be balanced against the costs involved in achieving it and the costs of alternative control steps, such as more stringent emission standards for new cars. Therefore, it is considered that, when all factors are taken into consideration, including the logistics of providing sufficient inspection stations, it would be premature to introduce a general requirement that all vehicles be inspected for emissions during yearly inspections for registration. It is considered, however, that for a pilot study, all state-owned vehicles, including the new ones, registered in Warsaw should be inspected for emissions and adjusted to minimize them during the yearly vehicle inspections. This pilot study will show the problems that may arise when introducing the system generally at some future time, say, 5 years hence.

Emissions from motor vehicles

An inventory of emissions from motor vehicles in a city is necessary to establish a relationship between emissions and air quality. With the exception of Warsaw, emission inventories, for motor vehicle emissions in cities, have not been completed. Some calculations of emissions on a national scale have been made, showing that emissions from motor vehicles contribute only a small part of the total emissions. Such calculations are of general interest and are not relating emissions to air quality. In the industrial areas of Poland, emissions from motor vehicles contribute 25% and more to the total emissions.

In the short time available for this study it was not possible to obtain exact data on the number of motor vehicles and the consumption of petrol and automotive distillate in the major cities of Poland. It, therefore, has not been possible to prepare emission inventories as intended, except for Warsaw, for which projections on the number of vehicles in the city have been made in a paper by Izabella Lisicka entitled "Air Pollution in Warsaw" (see table 4).

Table 4. Projections for increase of motor vehicles in Warsaw, 1975-1985

Type of vehicle	1975	1980	1985
Cars	126,000	222,000	310,000
Motorbikes and scooters	25,200	23,680	13,950
Trucks	23,800	26,640	29,450
Buses	3,220	3,700	4,650

Data on exhaust emissions from in-service vehicles in Poland do not exist and no typical driving cycle has been established. However, emission factors developed in the United States of America and modified for Polish conditions have been used as a first approximation of the emissions that are occurring.

II. RECOMMENDATIONS

On the basis of limited data available it was concluded that an air pollution problem from motor vehicles already exists in the central city areas of large cities such as Warsaw and Cracow. The rapid increase of motor vehicles will result in a rapid worsening of the problem unless control measures are commenced immediately. It is recommended that steps be taken:

1. To provide the necessary legal base for action;

2. To establish an organization with the authority and responsibility to control motor vehicle emissions;

3. To introduce interim control measures;

4. To determine or to confirm the actual concentrations of motor vehicle related pollutants in the ambient air;

5. To determine the actual emissions that are occurring from motor vehicles in Poland and to relate these to the air quality;

6. To prepare a control programme which will prevent any further worsening in air pollution levels arising from motor vehicles and ultimately bring about an improvement.

To implement these steps it is recommended that the following detailed action be taken.

A. Legislation

It is recommended that a new part be added to the Clean Air Act (196[illegible]) so as to provide for the control of emissions from any motor vehicle and to permit the prescription of national standards and other related regulations that may be necessary to control emissions from any motor vehicle. Broadly, the new part should contain the following provisions:

(a) A person shall not sell or use a motor vehicle if it emits air impurities in excess of the standard prescribed for the class of vehicles to which that motor vehicle belongs;

(b) A person shall not sell or use a motor vehicle which the regulations require to be fitted with a prescribed pollution control device unless it is fitted with such a device. The device must also be maintained in accordance with the regulations;

(c) Authority be given to the implementing organization (ministry) to require any information, including plans, specifications and performance data from the owner, including the manufacturer, about a motor vehicle or a class of motor vehicles;

- [illegible] given to the minister to permit [illegible] prohibit the [illegible] vehicles or any specified class of motor vehicles in any area [illegible] and at all times or during any times specified;

- Authority be given to the implementing organization (ministry) to require any manufacturer (Polish or foreign) of any new class of motor vehicle [illegible] an application for approval to sell that class of motor vehicle and [illegible] authority be given to refuse the application or approve it, subject to [illegible] conditions or unconditionally;

- prescribe substantial penalties for any person or organization [illegible] comply with any provision in the legislation: say Zl 75, [illegible] for [illegible] with Zl 15,000 day for a continuing offence and Zl 7,5[illegible] for [illegible] person with Zl 75 day for a continuing offence;

Authority be given to the Council of Ministers for the making of [illegible] for or with respect to:

(i) [illegible] standards of concentration or rates of emission of [illegible] impurities; the points at which such standards are to be determined and the method of making tests;

(ii) The installation, maintenance, testing, inspection and operation of pollution control devices in motor vehicles;

(iii) The operation of motor vehicles and fuels to be used in the operation of motor vehicles;

(iv) The inspection of motor vehicles and requiring motor vehicles to be tested to determine the emissions from them;

(v) Prohibiting or providing for the suspension of registration of any motor vehicle that does not comply with the regulations or national standards;

(vi) Exempting any persons or class of persons from any specified provision of the Act subject to conditions or unconditionally.

B. Motor vehicle emission control organisation

There is no organization in Poland with the necessary authority and responsibility for implementing legislation for the control of motor vehicle emissions. Furthermore, there is no organization which considers it has the responsibility to measure the concentrations of motor vehicle related pollutants in the atmosphere. The Research Institute of Automotive Engineering, the Aviation Research Institute and the Transport Institute have carried out measurements of emissions from new motor vehicles or motor vehicle engines but they have no executive authority to require control of emissions. These three Institutes have jointly drafted a branch standard to control emissions from new diesel engines and have almost completed a draft branch standard for emissions from motor vehicles with spark ignition engines. The Ministries of Ma

Industry and Transport have adopted the new diesel standard and are expected

to adopt the draft standard for new spark ignition vehicles. However, these are almost self-imposed industry standards and have not the force of law. Furthermore they may be inadequate to solve the problem.

Similarly in regard to in-service vehicles there are no standards in regard to emissions. The voivodship authorities through their registration inspection stations can refuse re-registration of vehicles which are smoking badly but this is by simple subjective observation rather than by any objective measurement.

To overcome the above deficiencies it is recommended that a small specialized organization be established within an appropriate ministry to develop and implement a programme of motor vehicle emission control and also to be responsible for the development of a programme for the measurement of the concentrations of motor vehicle related pollutants in the atmosphere.

This organization should work in close co-operation with the Research Institutes of the Ministries of Environment, Machine Industry and Transport but it should not be a part of any one of them. Logically, the proposed organization should be part of the Ministry of Environment as this Ministry has the supervising role, as far as the environment is concerned, and is completely independent from the motor vehicle manufacturing industry or the transport industry. Neither the Ministry for Machine Industry nor the Ministry for Transport could be expected to have a primary interest in control of emissions from motor vehicles which is so necessary for an effective attack on the problem.

It is considered that initially the proposed organization should be limited to 10 people as follows:

1 Branch chief (engineer)
1 Senior engineer
1 Engineer
1 Scientific officer
1 Senior inspector
3 Inspectors
1 Technical officer
1 Technical assistant

The work to be carried out will be specialised, highly technical, with considerable public relations over-tones.

The primary task would be to prepare National Emission Standards for motor vehicles, both new and in-service, together with any necessary regulations. The [illegible] organization would also be responsible for the implementation of the [illegible] in collaboration with the Institute of [illegible] as far as the measurement of air quality is concerned; with the Institute of [illegible] as far as certification testing of new vehicles is concerned; with the Institute of Automotive Engineering and the Aviation Institute as far as [illegible] vehicle emission measurement and the development control methods are concerned; and with the voivodship inspection stations as far as registration testing for emissions is concerned.

The proposed organization would also be required to develop a programme [illegible] changes in the procedures to be used to adjust and [illegible] control equipment and carburettors so as to minimize emissions. It is anticipated that this programme would be carried out in collaboration with the technical and trade education colleges, with the voivodship inspection stations and with transport authorities operating large fleets of buses and trucks.

In addition the proposed organization would provide the technical staff to assist in the development of emissions and air quality measurement programmes as recommended in section D of this chapter.

It is envisaged that the staff of the proposed organisation would be control oriented rather than purely measurement or research oriented. Ideally, the chief should have extensive knowledge of motor vehicle emissions and their control together with a general knowledge of ambient air quality measurement and data processing. The professional staff would need to have an adequate professional background to be able to develop methods for relating motor vehicle emissions with air quality so that they could develop progressively the controls that are necessary to maintain a satisfactory air quality in the face of an increasing number of vehicles.

The inspectors and technical officers would, initially, direct their attention towards controlling emissions from in-service vehicles, particularly smoke, but subsequently, once knowledge and experience are gained, invisible emissions. These officers would also train the personnel of inspection stations and of public transport authorities on the measurement and control of emissions.

Expansion of the proposed organisation would depend on a demonstrated need and also on its proven effectiveness. A similar approach for the control of noise emissions from motor vehicles would be a logical development.

7. Interim control measures

A number of control measures could be taken immediately. They would impose negligible costs on the community but they would make significant reductions in emissions. It is, therefore, recommended that the following steps be taken either under existing legislative or government powers or as soon as the proposed amendments to the Clean Air Act are enacted:

(a) Apply the branch standards for prototype diesel engines and spark ignition vehicles to a random sample of new production vehicles and engines. The random tests could be carried out by the Institute of Transport as its facilities appear to be under-utilized at present. Vehicles or engines that fail the test should be corrected by the manufacturer before they are sold;

(b) Prepare national standards equivalent to ECE 15 (1969) and [illegible] for proclamation as soon as the proposed amendments to the Clean Air Act are enacted;

(c) Prepare a draft national standard prohibiting the emission of visible air impurities (this excludes water vapour) from any motor vehicle, both new and in-service, for more than 10 seconds. Until proclaimed this draft regulation could be applied to all government vehicles so that experience in its implementation is obtained;

(d) Install M.E.A., A.D.I.P. or caustic treating units in oil refineries so as to remove mercaptan and other odorous compounds from petrol and so reduce the odorous emissions that are at present occurring from spark ignition vehicles;

(e) Develop and introduce an education and training programme for motor mechanics, so they learn to tune vehicles for minimum emissions and satisfactory performance rather than for performance alone.

(f) Publish pamphlets on the control of smoke from motor vehicles and on emissions from motor vehicles generally and distribute them widely so as to make owners and operators aware of the problem and the action they can take to improve the situation;

(g) Require inspection stations to carry out idle emission tests on all new spark ignition vehicles purchased by the State, both, before initial registration and at all re-registrations, to determine whether the exhaust concentration of carbon monoxide exceeds 4.5% and, if it does, to adjust the concentration to below 4.5%. (This would ensure that stations will be equipped with adequate measuring instruments and inspecting staff will be trained in measuring techniques. At the same time, the stations will not be overloaded with more inspections than they can handle);

(h) Prepare a draft regulation requiring the installation of a vertical exhaust pipe not less than 3 m high on all new diesel vehicles having an unladen mass of more than 2.5 tons or a gross vehicle mass of more than 4.5 tons by 1 January 1978;

(i) Examine the practicability of amending the national standards for automotive distillate fuel so that the maximum allowable sulphur content is reduced to 0.3% by 1 January 1978;

(j) Give notice that the national emission standards for new spark ignition engines are to be made identical to the amended ECE 15 standard (which commenced to operate in Western Europe from 1 October 1975) by 1 October 1977.

5. Air quality and emission measurements

In order to establish present and future emission control requirements for motor vehicles, it is essential to have base-line data on the existing air quality in regard to motor vehicle related pollutants together with data on the emission from the vehicles in the area under consideration. The limited data that exist on air quality in Poland need to be confirmed and extended. There are virtually no data on in-service vehicles except for those data obtained by the Research Institutes and the motor vehicle manufacturers for new vehicles which have since become in-service vehicles.

To obtain the necessary data on air quality and emission and to develop the relationships between them, it is recommended that a project steering committee be established under the authority of the Ministers for Environment, Automotive Industry and Transport. This committee should comprise representatives of the three ministries and also their research institutes together with representatives of UNIDO. The task of the committee should be to prepare a project document on the determination of the levels of motor vehicle related pollutants in selected Polish cities, say, Warsaw, Cracow, Lublin, Gdańsk, and Łódź, and to plan a survey of a representative sample of, say, 300 in-service vehicles, randomly sampled in Warsaw, to determine the actual emissions that are occurring in the city. The selected vehicles would be tested for emissions on a chassis dynamometer over a cycle that represents more accurately the average driving cycle in Polish cities than does the ECE cycle.

From the results of the survey and taking into account the projected increase in the various types of vehicles a programme of reductions in emissions would be developed. The programme would be a follow-up of the interim measures already proposed and would be likely to include controls in the form of national emission standards and regulations for pollution control devices on vehicles.

The question of financing the proposed project is one for negotiation between UNIDO and the Polish Government. There is little doubt that the project could only be conducted if there was a substantial contribution from UNDP or UNIDO funds. Air pollution monitoring and emission testing equipment would be required and much of this, being of a specialised nature, could only be obtained from Western Europe, the United States or Japan. Details of the equipment considered necessary to conduct the project together with approximate

[illegible] and possible suppliers are shown in Annexes I and II. It will be noted that the estimated cost for emission measuring equipment is $[illegible] and $[illegible], for air pollution monitoring equipment making a total of $[illegible].

As the proposed air quality and emissions studies are being carried out, a start should commence on the preparation of mathematical models relating emissions to air quality in selected cities. The simplest model to construct will be one for carbon monoxide in Warsaw and Cracow and it should be commenced first. Subsequently, other models relating emissions of oxides of nitrogen, hydrocarbons and suspended particulates to ambient air quality may also be undertaken. No attempt should be made to develop a model directly relating emissions to photochemical pollution until measurements of ozone concentrations show this to be necessary.

On the basis of the relationships developed between actual emissions and air quality together with the projected increases in motor vehicle populations a programme could be prepared for progressively more stringent control, so as to ensure that an air quality is achieved and maintained which satisfies the national ambient air quality standards. Where such standards have not yet been proclaimed, the WHO long-term goals for carbon monoxide and oxidants are recommended for adoption for protected areas in Poland.

F. Fellowships

It is recommended that in addition to his present programme, P. Broszkowski, whilst in the United Kingdom, be required to study the control of smoke and odours from diesel vehicles and to visit the Environmental Control Organizations listed below. If necessary his fellowship should be extended to permit this.

Organization	Topic
C.A.V.	Smoke and odour control
British Internal Combustion Engine Research Institute	Smoke and odour control
Department of Environment, London	Pollution control philosophy
Transport and Road Research Laboratory, Department of Environment	Emission testing
Octel Ltd. Bletchley Development Laboratory	Computer controlled chassis dynamometers
Ministry of Transport, London	Development of lead filters Enforcement procedures
Warren Spring Laboratories, Warren Spring	Air quality monitoring Lead emissions from operating vehicles

It is also recommended that in addition to his present programme Mr. Wisniewski, whilst in France and West Germany, be required to study developments in the design of the stratified charge engine and to visit the Environmental Control Organizations listed below. If necessary his fellowship should be extended to permit this.

Organization	Topic
Technical University, Aachen	Stratified charge engine development
Fachhochschule, Munster (Professor Tromm)	Stratified charge engine development
Ministry of Environment, Paris (Mr. Sorets)	Pollution control philosophy
Prefecture de Police, Paris (Professor Thovun)	Measurement of motor vehicle emissions
State Institute of Air, Water and Noise Control, Essen (Dr. Strattman)	Measurement of air quality
Ministry of Environment, Bonn (Mr. Katin)	Pollution control philosophy
Volkswagen A.G. Daimler Benz A.G., Stuttgart Technical University, Vienna	Developments in emission control

Annex I

EQUIPMENT FOR MEASURING MOTOR VEHICLE EMISSIONS

Equipment	Number required	Cost per unit ($)	Total cost ($)	Possible suppliers	Purpose and remarks
Non-dispersive infra-red carbon monoxide analyser for the determination of the carbon monoxide concentration in the exhaust gases from a motor vehicle. Complete with recorder.	1			AVL (Institute for Combustion Engines), Graz, Austria	These instruments would be used to measure CO, HC and NO_x emissions from a sample of, say, 300 in-service vehicles to determine base-line data for emissions from motor vehicles in Polish cities. It would be necessary to operate the vehicles on a chassis dynamometer over a cycle which more closely represents Polish conditions than does the ECE cycle. The US 1973 and US 1975 cycles would be more appropriate. Existing Polish facilities are either not equipped with the required equipment or are fully committed to other research and development work or in checking compliance of production vehicles. Hence, additional analysers capable of testing to the equivalent of the US standards would be required to carry out the proposed survey. The equipment could subsequently be used in the development of control devices or low emission engines and in the implementation of any standards that may be proclaimed. The three analysers could be arranged in a cart from which connections can be made directly to the CVS sample for continuous measurement during test or for analysis of bag samples. A chassis dynamometer of Russian manufacture is being installed at the Institute of Automotive Engineering and this sampling and analysis equipment could be coupled with it.
Flame ionization detector analyser for the determination of the total hydrocarbon concentration in the exhaust gases from a motor vehicle. Complete with recorder.	1		32,000	Olsen Laboratories, Cal., USA Philco Ford, Cal., USA Beckman Equipment Co, Cal., USA Hartman und Braun, Frankfurt, Federal Republic of Germany	
Chemiluminescent analyser for the determination of the oxides of nitrogen concentration in the exhaust gases from a motor vehicle. Complete with recorder.	1				
Constant volume sampler capable of pumping at a constant rate of 8.5 m^3/min.	1		25,000	Scott Laboratories Philco Ford Olsen Laboratories	
Sampling lines, sampling bags, etc.			1,500	Relevant suppliers	
Standard gases, in bottles					
Propane in air	3	250	2,250		
Carbon monoxide in nitrogen	3				
Nitric oxide in nitrogen	3				

Equipment	Number required	Cost per unit $	Total cost $	Possible suppliers	Observations
Portable infra-red carbon monoxide analyser for determination of carbon monoxide concentration in exhaust gases from a motor vehicle. **Range:** 0-12% CO **Weight:** 6 kg max. To be supplied with calibration gas having concentration 4-6% CO				[illegible] Hartmann und [illegible] Intralyt, German Democratic Republic	[illegible] with instruments for measuring the carbon monoxide [illegible] of gases of [illegible]. [illegible] max. [illegible] would [illegible] required for calibration purposes, one [illegible] Institute of Transport and one other [illegible] Institute of Automotive Engineering. Note: further instruments would be required to equip the four inspection stations [illegible] study showed in-service testing practical.
Portable smoke meter operating on the photoelectric principle for the measurement of smoke density of gases from a motor vehicle. The photoelectric device should be capable of being clamped on the exhaust pipe and only electrical leads are to be taken to a remote meter. **Weight:** 6 kg max.	2	[illegible]	[illegible]	Solid State Equipment Ltd., Lower Hutt, New Zealand Telesco Industries, Costa Mesa, [illegible]	In examining the practicability of developing a numerical standard for the emission of smoke from in-service vehicles in [illegible] it will be a research task and should therefore be carried out by a research institute such as the Institute of Transport Engineering or the Transport Institute. Note: further instruments may be required in the future.
Hartridge Mark 3 smoke meter for measurement of smoke emissions from engines on an engine dynamometer or a chassis dynamometer.	2	[illegible],000	[illegible],000	Hartridge, England	This instrument is required for studies of emissions of smoke from diesel vehicles or diesel vehicle engines operating on dynamometers to aid in development of engine designs. The Aviation Institute needs such an instrument and a second would be required for a survey of emissions from in-service ver[illegible]
Data acquisition and storage system to scan and record outputs from analytical instruments in digital form. System should have capacity for 13 input channels and should record on a tape compatible with mini computer.	1	[illegible],300	[illegible],300	Suppliers of analytical equipment could supply suitable acquisition and computer equipment.	[illegible] required for receiving and storing data in computer compatible form.
Mini computer suitable for processing data from motor vehicle emission testing	1	10,000	[illegible]	Suppliers of analytical equipment could supply suitable acquisition and computer equipment [illegible] USA suggested:	Required for processing and evaluating test data. [illegible] or [illegible] or equivalent
Total			[illegible],850		

Annex II

MONITORING EQUIPMENT FOR AMBIENT AIR POLLUTION

Equipment	Number required	Cost per unit ($)	Total cost ($)	Possible suppliers	Purpose and remarks
Continuous infra-red carbon monoxide analyser, complete with recorder and sampling, handling and conditioning system. Range: 0-250 ppm, 220 V, 50 Hz	3	8,800	26,400	Beckman Equipment Co., Cal., USA Safety Applicance Co., Pittsburgh, USA The Bendix Corp., Ranceverte, W.Va., USA	For continuous measuring of CO in central city areas of Warsaw, Cracow and Łódź.
Portable continuous carbon monoxide analyser, complete with portable recorder. Multi range: 0-100, 0-500 ppm, 220 V, 50 Hz	5	1,750	8,750	Energetics Science Inc., New York, USA	For continuous short-term measurement of CO in various locations in Warsaw, Cracow, Łódź, Lublin and Gdańsk.
Continuous chemiluminescent ozone analyser (ethylene reaction type), with built in calibration and thermoelectric stabilization. Complete with recorder. Range: 0-0.2, 0-0.5, 0-1 ppm, 220 V, 50 Hz	2	5,000	10,000	The Bendix Corp. Monitor Labs Inc., San Diego, Cal., USA	For continuous measurement of ozone 5-10 km down-wind of major precursor sources in Warsaw and Cracow and, subsequently, Gdańsk and Lublin.
Continuous chemiluminescent oxides of nitrogen analyser for simultaneous measurement of nitric oxide, nitrogendioxide and total oxides of nitrogen, complete with three pen recorder. Range: 0-5 ppm, in steps. 220 V, 50 Hz	1	7,500	7,500	The Bendix Corp. Mine Safety Appliance Co. Monitor Labs Inc.	For continuous measurement of oxides of nitrogen in Warsaw. (There is a lesser need for this instrument that for the items listed above during the initial stage of the project.
Flameionization detector for simultaneous measurement of methane and non-methane hydrocarbons. Complete with two pen recorder and sample handling system including catalytic oxidizer or equivalent for burner support air and zero air. Range: 0-100 ppm, in multiple steps, 0-5, 0-20, 0-100 220 V, 50Hz	1	10,000	10,000	Mine Safety Appliance Co. Hartmann und Braun, Federal Republic of Germany Beckman Equipment Co. Tracor Analytical Instrument Co., Austin, Tex., USA	For continuous measurement of hydrocarbons in Warsaw. (There is a lesser need for this instrument than for the items listed above during the initial stage of the project.

Equipment	Number required	Cost per unit ($)	Total cost ($)	Possible suppliers	Purpose and remarks
Dynamic calibration system for calibration of NO, NO_2, SO_2 and O_3. Continuous analysers complete with constant temperature oven(s) (± 0.1°C) for permeation sources, an ozone generator and a system to produce clean, dry zero air	1	4,000	4,000	The Bendix Corp. Monitor Labs Inc.	For accurate calibration of continuous analysers.
Calibration gases-gold standard, in bottles 100 ppm NO in nitrogen 100 ppm CO in nitrogen 200 ppm CO in nitrogen 500 ppm CO in nitrogen	1 1 1 1	250	1,000	The Bendix Corp. Monitor Labs Inc. National Standards Laboratory, Washington, USA	For accurate calibration of continuous analysers
Permeation sources for nitrogen dioxide and sulphur dioxide			400	The Bendix Corp. Monitor Labs Inc. Environment and Protection Agency, N.C., USA	For accurate calibration of continuous analysers.
Replacement filters etc. and spare parts for components susceptible to wear or breakdown	-	-	5,000	Relevant suppliers of analysers	To ensure minimum down time for analyser. If agencies of overseas suppliers exist in Europe then they should be required to carry spare parts. Similarly, European suppliers should be required to carry spare parts.
Data acquisition and storage system to scan and record outputs from monitoring instrument in digital form. System should have capacity for 13 input channels and should record on magnetic tape in a form compatible with Polish computers	2	6,300	12,600	Westinghouse, USA D. Mac, Glasgow, UK Schlumberger Instrumentation Australia Pty Ltd Polish Manufacturers	This equipment will be necessary after experience is gained in operating analysers. Polish authorities are developing suitable equipment.
Total			85,650		

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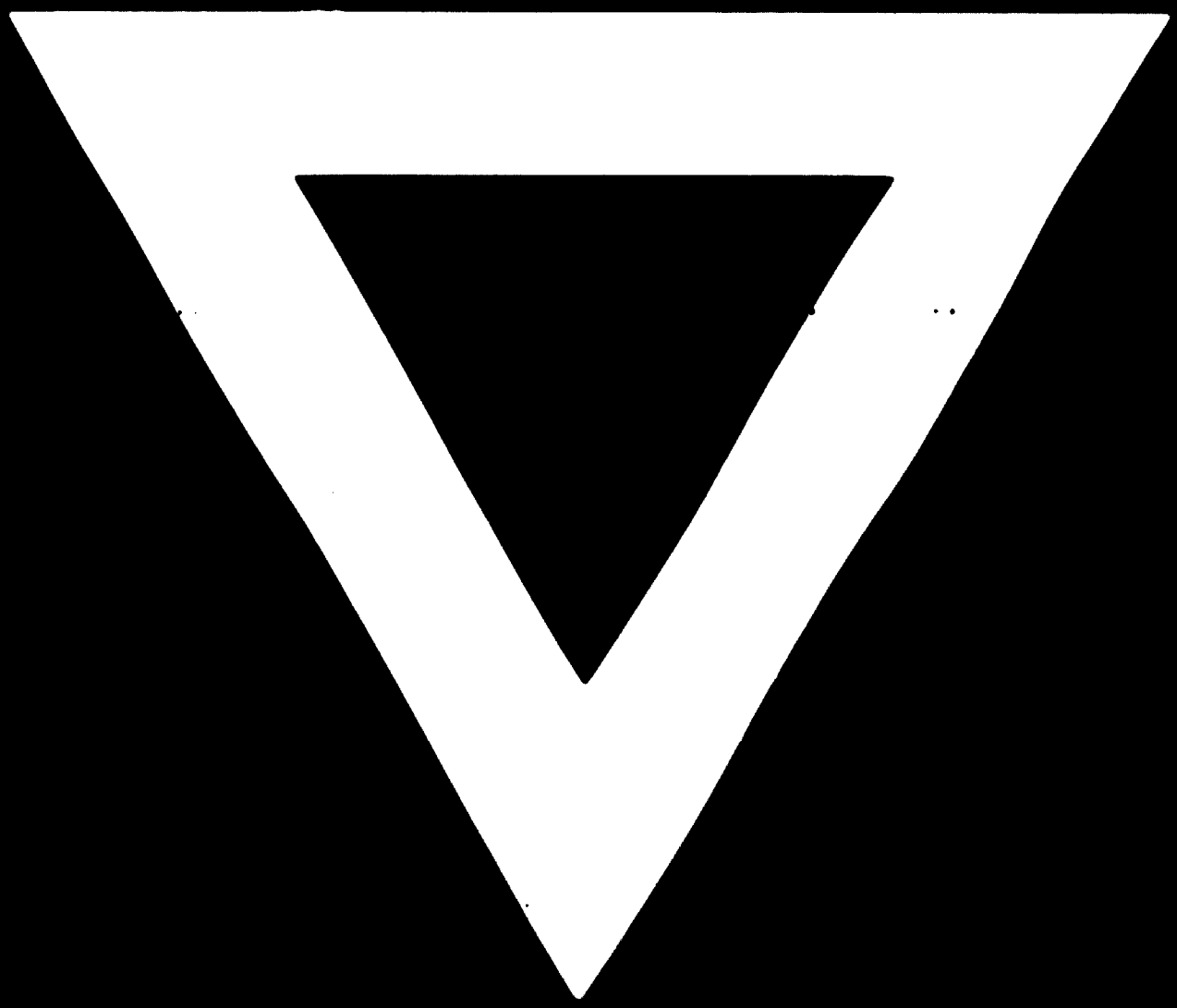

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