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ECOLOGICAL ASPECTS OF THE ENVIRONMENTAL IMPACT OF THE RUBBER INDUSTRY 1/

by

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SUMMARY

This paper reviews only the physical aspects of human ecology related to the industry. It does not consider the broader aspects of the industrial and social impact.

Warning is given on the risks arising from some of the broad generalizations made, and the need to consider each individual plant and process is stressed.

The principal sections of the paper consider natural rubber production , synthetic rubber manufacture, the processing industry, the use of rubber products, the reclaim industry, and the disposal of rubber products.

The principal sections are subdivided into the routes of environmental impact, distinguishing between the public environment and the working environment. The first is divided into sections on air pollution, water pollution, land contamination, and noise. The second considers exposure to toxic substances and noise.

In general the rubber industry does not present a major risk to the human environment, and many of its minor problems are common to other industries (e.g. air pollution from heating plant, oil in water).

At the manufacturing stage, problems of water pollution are paramount; at the processing stage, the effects of occupational exposure on human health must be of principal concern.

Problems of disposal of products generally involve aeshetic and economic considerations to a much greater extent than those of health.

Criteria for air pollution, water pollution, and noise are presented in three annexes to the paper.

INTRODUCTION

The word "environment" is nowhere defined precisely; it means in general terms "the surroundings of". In this text it is taken to mean the physical surroundings of people working in or living near the rubber industry.

In the broadest sense, three aspects of human ecology - the study of the environment as it affects man- can be identified:

1. The Physical. This is concerned with those factors in the surroundings that affect the health and welfare of people, such as air and water pollution, exposure to toxic materials and noise.
2. The Industrial. This is concerned with factors affecting the organization of the industry, such as the location of the industry, the financial arrangements for its construction and operation, the provision of roads, docks, and other services.
3. The Social. This is concerned with factors affecting the social organization, such as the construction of new communities, the influence of industrial work on existing social structures and the provision of health services.

This paper is restricted to the first aspect but considers it in the broadest sense. It is necessary to emphasise at the outset the risks and errors that arise in broad generalizations. It cannot be stressed too strongly that each plant will have its own environmental problems depending on the processes and substances used, and on its local environment. This paper can only identify those problems that have common occurence and which are generally recognized. Whether a problem actually exists depends on the inherent potential risk and on the control measures taken. Thus, waste water discharges to a tidal sea are inherently less likely to create environmental problems than discharge to an inland river. Nevertheless, the introduction of strict monitoring and control of the latter may make it less environmentally damaging than the sea discharge for which less strict control is enforced.

The proper selection of location for operations can do much to minimize environmental impact; for example, noisy process operations should be located away from residential areas.

From initial review of the published literature it appears that the rubber industry does not represent a comparatively major hazard to the public environment. Very little data have been traced in the English language, though a number of articles have appeared in the Russian literature, and a few in Swedish and the East European languages. There is however a large literature in a number of languages on the environmental problems within the industry itself, particularly in the field of industrial toxicology. This arises from the inherent toxicity of some of the additives used in the processing of rubber and the extent of personal contact in many operations.

It can be deduced, therefore, that the principal environmental problem is that of occupational exposure; nevertheless, the total environment must be considered, largely on the basis that it may present potential rather than proven risks. It is to be hoped that the expert committee will provide the data for enumerating the potential risks described.

Distinction between effects of natural and synthetic rubber

Clear distinction can only be made at the manufacturing stage. In latter operations the products are generally mixed and so specific problems of each cannot normally be identified.

Even at the manufacturing stage difficulties arise in making a direct comparison of environmental impact of synthetic and natural rubber. Natural rubber manufacture takes place in widely dispersed areas in developing countries, whereas synthetic manufacture is a highly concentrated operation in developed countries where much higher priority can afford to be given to adverse environmental effects and to long term health effects. Also, in the broadest concept of environment, balance must be made between relative advantages of high manpower requirements in developing countries to create initial employment, and the low manpower objective in developed countries to maintain high earning capacity. Also, in considering land usage, in some developed countries land is at a premium and its use must be strictly controlled for economic reasons. In developing countries large areas of land may be available for manufacture (it is reported that about 2 million hectares in Malaysia are devoted to rubber manufacture); this might eventually limit the greater development of land given to food production. Thus, it should be considered whether the use of oil as a feedstock for synthetic rubber has a greater or lesser long term environmental impact than the occupation of potential food producing areas for natural rubber production. This question is largely hypothetical as the situation is controlled by economic and political factors, but serves to show the difficulty of making direct environmental comparison of the manufacture of the two classes of product.

A more direct comparison can be made when selecting waste water treatment methods as these may well depend on the economic and physical environment. For example, at a synthetic rubber manufacturing plant the cost and technical requirements of a two or three stage mechanical cleaning system may be selected, whereas for natural rubber production it may be more economic to give over large areas of land to oxidation pond treatment.

In this text the two primary manufacturing industries will be considered separately.

NATURAL RUBBER PRODUCTION

This is undertaken on estates or smallholdings in generally developing countries, and often in underdeveloped communities. It is a dispersed industry and probably has widely varying environmental problems. Common potential problems are here considered under separate headings according to the environmental impact. It should, however, be stressed that some substances may represent an environmental hazard in several different forms. For example, the use of pesticides may represent an air or water pollution problem, may contaminate land and restrict its subsequent use, or be an occupational hazard to the user. Generally, reference is made here to the greatest potential risk.

The Public Environment - Air Pollution

There do not appear to be any well recognized air pollution problems related to the production of natural rubber, though the use of herbicides and pesticides presents potential risks, and fertilizers can possibly create airborne dust problems.

The initial processing of the collected latex may give rise to release of sulphur oxides in the combustion products of the fuel used for drying, and probably to a lesser extent may produce smoke from incomplete combustion or from the deliberate smoking of some products. If carbon black is incorporated into master batches at this stage of processing, it may well give rise to nuisance discharges to the general atmosphere. The release of odiferous vapours, such as ammonia or mercaptans, may also create a local nuisance.

A specific problem of airborne smoke arises when it is necessary to eliminate yellow leaf blight by burning extensive areas of rubber trees. Careful selection of weather conditions and wind direction may reduce the risk of excessive human exposure to smoke.

Air pollution criteria are discussed in Annex 1.

- Water Pollution

The principal problem of water contamination is likely to be discharge of effluent containing skim. This may contain a high concentration of suspended solids and have a high biological oxygen demand (BOD). This may kill fish in inland waters, particularly when dilution is reduced in the dry season. It is understood that, under the new Malaysian Environmental Act, regulations to limit these discharges have been made. Risks associated with the discharge of dilute coagulants, such as formic, picric, acetic or sulphuric acids, are unknown. The preservative ammonia also creates a high BOD in waste water and is a potential hazard to fish, though it may be reacted with spent acid to produce a fertiliser for direct application to the land. The presence of ammonia in the wastewater may encourage desired algal growth in oxidization pond treatment of the effluent. Pentachloropheanol may also be used as a preservative; this is recognized to be highly toxic to fish and its concentration in waste water must be strictly controlled. The range of herbicides, pesticides and fertilizers used all have potential for water pollution, and must be excluded from surface water by sound methods of application. Particular reference should be made to the risks associated with the discharge of the bactericides used for treating the processing plants as these may well have serious effects on the receiving waters.

In considering the risk of discharge of chemical products to surface water, not only must local ecological factors be considered, but also the ultimate use of that water, particularly if it is a source of drinking water for humans or animals. Safe limits for discharges can only be developed in relationship to the local conditions, taking into account the factors mentioned above.

Criteria for water pollution and methods of control are discussed in Annex 2.

- Land Contamination

Of basic concern must be the effects of change of land use associated with the production of rubber. Although in principle these should be beneficial if the trees are to prosper, any side-effects should be observed and controlled. For example, soil drainage may cause undesirable effects downstream. The regular spraying of trees with insectides may lead to concentrations building up in soil, which although of no concern while rubber is produced, may preclude subsequent use of the land for growing foodstuffs due to unacceptable levels of the substance appearing in the food.

The dumping of solid wastes if properly controlled and if toxic substances are excluded is an acceptable practice. Fundamentally it may be wasteful of resources but economic factors rather than technology restrict the general application of recovery methods (such as distillation for motor fuel or lubricants). Reference has already been made to the desirability of neutralising coagulated skim rubber and its application as a fertilizer.

- Noise

Problems of neighbourhood noise are only likely to be significant where mechanical plant is installed near residential areas. For example, blowers on drying units are a potential cause of complaint if people sleep nearby.

Noise criteria are discussed in Annex 3.

The Working Environment

Workers on estates and small-holdings are exposed to the hazards of the natural environment arising from animals, insects and plants. Experience will have taught most to minimize the traditional hazards, and some, such as malaria, are the subject of public health programmes. New problems may exist which require investigation and control. These range from toxic hazards of pesticides and herbicides to noise and vibration hazards from portable power saws. It is understood that the use of highly hazardous sodium arsenite has ceased, and modern spraying chemicals are normally supplied with safe usage instructions. It is important that all those employed in the use of such products should be properly instructed in the precautions necessary to protect themselves and the natural environment. It is essential that safety instructions should be translated into the language of the user.

Other hazards arise in the working environment where latex is processed for shipment. Chemical hazards include the coagulants, picric, acetic and sulphuric acids. Skin and eye protection is essential for handling strong acids, and ventilation control may be needed for volatile acids, such as acetic. Ammonia used as a preservative is highly irritant if inhaled and represents a severe hazard in a confined space. Sodium sulphite may also be used but is not a toxic hazard. Pentachlorophenol which is sometimes used is a significant health hazard if inhaled and can also penetrate through the skin, particularly if in an organic solvent. The use of talc to prevent surfaces adhering represents a hazard to the lungs if inhaled, and is likely to require the use of extract ventilation to control. Exposure to products of combustion including smoke may require control. Physical factors requiring investigation and possible control are heat and noise. It is not known whether epidemiological or environmental surveys have been undertaken to quantify these possible environmental hazards. Standards have been established for most at the national rather than the international level.

It is important that measurements of the environment be made to assess exposure, and routine monitoring programmes instituted if found necessary. With the increasing introduction of power equipment (e.g. power saws), noise and vibration hazards are likely to increase. These will require evaluation and control.

Shipping of Natural Rubber

It is believed that no specific environmental hazards arise in the shipping of natural rubber products to the processing operations.

SYNTHETIC RUBBER MANUFACTURE

Synthetic rubber is manufactured from petroleum feedstocks, generally in large integrated plants which may share common environmental control facilities with the supplying plant. Although the potential risk to the neighbouring environment and to workers may be significant, in practice the centralization, high capital investment and limited number of highly trained operators permits more effective detection and control of hazards than is likely in a widely dispersed industry.

The Public Environment - Air Pollution

No significant routine release to the general atmosphere should occur from a modern plant that is properly designed and operated.

Releases may occur through accidents or through abnormal operating conditions (e.g. start-up), and provision must be made for minimizing ill-effects at these times. Although managements have a strong incentive to reduce the number and duration of these events to a practicable minimum, there may be little economic incentive to protect the environment, and urgent operational decisions may not take proper account of environmental consequences.

As for any plant requiring heat, products of combustion of fuel may be discharged. No significant concentrations of particulate matter should be present in the stack gases, and the concentration of sulphur oxide in the discharge will depend on the sulphur content of the fuel burned. Generally these form the basis for stack height design. Nitrogen oxides, carbon monoxide, and carbon dioxide are also discharged but not normally in environmentally significant quantities.

Hydrocarbon vapours and droplets may be discharged to atmosphere, but only under accident conditions will these be in significant amounts as vapour recovery systems are normally fitted where release may be significant. Of particular environmental concern is ethylene, as it is highly damaging to certain sensitive plant species. Release of highly toxic volatile substances such as benzene and acrylonitrile requires strict control, and disaster planning may be needed where these are stocked in large quantitites near areas of public access. Flaring of vapours should be required only occasionally and is likely to require smoke and noise control. Where photochemical smog may occur, rubber manufacturing plants may contribute to the atmospheric load of hydrocarbon precursers, and special attention must be given to minor leakages.

Odorous emissions to atmosphere may occur, particularly during the regeneration of catalysts, and waste water treatment is also liable to cause environmental odour problems which can be difficult to control. The introduction of carbon black into master batches reduces dust problems in the processing industry, but demands proper control procedures at manufacturing plants. Fortunately this is more readily achieved in larger units that can carry the cost of environmental control equipment.

- Water Pollution

The release of hydrocarbons in waste water calls for effective monitoring and control of operations on the plant, as well as the provision of an effluent treatment plant (e.g. as a minimum, an oil separator and flocculator). The extent of the treatment will depend not only on the scale and nature of the manufacturing process, but also on the nature of the waters to which the effluent is released. Water soluble substances may be a particular problem to control, and at the opposite extreme insoluble resinous substances can rapidly block drainage systems.

A number of specialized products (e.g. detergents, emulsifying or foaming agents) may make treatment difficult. Acids, brines and chlorides may be present, and conventional contaminants may include water treatment chemicals from boiler blow-down.

The manufacture of latex gives rise to high concentrations of suspended solids and high BOD and COD (chemical oxygen demand) and is likely to require specialized treatment equipment. It should, however, be noted that any rubber like substance present in the liquid effluent will serve to absorb many other chemicals that may be present in small quantities, such as tertiary butyl catechol.

The use of alum or iron salts as flocculating agents for water treatment makes for a bulky product for disposal and the use of poly-electrolyte alone is better if found feasible.

Criteria for liquid effluents and methods for their control are discussed in Annex 2.

- Land Contamination

Solids for disposal comprise those recovered from water treatment, off-grade product that cannot be recycled, spent catalysts, and the normal refuse developed on industrial sites. Solids and sludges from water treatment are amenable to disposal by incineration in specially designed systems for smoke-free combustion, alternatively these and other substances regarded as non-toxic may be disposed of as landfill. As this can be regarded as a form of uncontrolled and indefinite storage, many managements prefer to restrict it to land within the plant boundary.

- **Noise**

Noise may well give rise to complaints if the plant is operated near a residential area as conventional noisy equipment is generally used, - furnace burners, pumps, motors, air-fin coolers, pipeline valves, etc. Standards are available for judging conditions, and methods for reducing the problem are known.

The Working Environment

The principal toxicity hazards arise from accidental releases of volatile substances used in the processes, particularly acrylonitrile, benzene, ethylene dichloride, and methyl chloride. Less hazardous substances (e.g. styrene) may also create riks in confined spaces. Most of the substances used are flammable so fire and explosion hazards require assessment and control. The mercaptans that may be used are both toxic and objectionable, and may create a neighbourhood odour nuisance. Hydroquinone may cause dermatitis, high concentrations are toxic, and lower levels may damage the eyes.

The catalysts used may present hazards as they may be dusty, and some are highly reactive (e.g. aluminium chloride) and create serious lung hazards. Boron trifluoride is potentially highly hazardous as it hydrolyses in moist air to hydrofluoric acid. In practice it has proved not too difficult to handle. The handling of acids and alkalies requires the use of suitable eye and skin protection. If isocyanates are handled strict precautions must be taken to avoid inhalation and skin contact.

Noise induced hearing loss is a potential hazard on any large scale plant where locally high noise levels may be encountered. Noise exposures need to be compared to accepted national standards, and if necessary noise controls introduced.

THE PROCESSING INDUSTRY

The processing of rubber into products is a widely dispersed industry with strong traditional practices. Environmental problems seldom arise from the rubber (either natural or synthetic) itself, but from the many additives used in the processes. The industry has its share of occupational health hazards due to the diversity and often uncertain toxicity of the products handled, and to the great extent of human contact in the processes.

In this draft no attempt has been made to distinguish problems arising from the alternative raw materials, as they depend more on the final product produced, though this itself may influence the choice of rubber.

The Public Environment - Air Pollution

The handling of carbon black, and particularly its manufacture, has a high potential for creating a nuisance in the neighbourhood. This is recognized in modern plants and air pollution is successfully controlled. Problems in the process industry have been enormously improved by the availability of carbon black incorporated in master batches. Careful control of particle size in manufacture reduces contamination, and the bulk handling of the power enables stricter confinement to be obtained.

One processing organization has made the sensible decision to restrict the use of carbon black to a single plant which is equipped with the necessary control equipment; all other plants receive master batch containing the carbon black from this central facility.

Generally vulcanization does not now create an air pollution problem; if excessive amounts of sulphur monochloride fume are released, they can be trapped in an alkali scrubber system. Similarly, hydrogen sulphide released during vulcanization of ebonite can be trapped.

It has recently been recognized that toluene diisocyanate used in foaming operations can represent a hazard in the neighbourhood of the plant, as well as presenting a risk to those employed in the process. In the United Kingdom the following formula has been developed to specify the needed height of stack for discharging vapour from TDI foaming operations:

$$h = \sqrt{0.6\ V\ C}$$

h in feet
V in cubic feet per minute of discharge, containing
C concentration in ppm (v/v)

The handling of asbestos and of talc may create unacceptable levels of these dusts in the neighbourhood. Considerable quantitites of white spirit and other hydrocarbon solvents are used in some processes but there is no evidence that their evaporation causes neighbourhood problems. For special operations such as the manufacture of industrial gloves by dipping, solvent recovery plants are necessary on extract systems.

Where economically feasible it is desirable to restrict the concentration of toxic substances in atmospheric discharges to that permitted in the working environment. Where this is not possible, it is necessary to calculate ground level concentrations in the most critical public area and apply an appropriate standard derived from national or international sources. This is particularly relevant to the concentration of sulphur dioxide produced in the neighbourhood by steam raising and heating plant.

The Public Environment - Water Pollution

This is generally much less of a problem than that arising in manufacturing either natural or synthetic rubber. For many plants the principal problem is the exclusion of lubricating oils from waste water systems. Simple interceptors should be installed on every waste line and regular checks made for their loading with oil.

As a general rule, it is considered good practice to segregate sewer systems to separate rain run-off, cooling water and water from process areas, as well as domestic sewage. For example in the United States it is recommended practice to cover areas where spillage may occur (e.g. vehicle loading or unloading with liquid products) so that the volume of liquid passing to the drain is very small and readily handled when compared with the volume of run-off from the area during rain. In the United Kingdom, one plant uses a process involving a strong chemical cleaning agent; although this may not be discharged with other liquid effluent to the local river, it is accepted by the community sewage treatment plant via the domestic sewer.

Latex operations may create serious water pollution problems, producing high levels of suspended solids and high BOD/COD. Not only may latex particles be discharged but also ammonia and its salts, fluorides, detergents and foaming agents. Free ammonia is removed at one location by air blowing, reducing it from 0.6 ppm to 0.1 ppm, without creating an air pollution problem.

- Land Contamination

In general, solid wastes arising from rubber processing are classed as non-toxic and can be used as land fill. Exceptions are materials containing significant concentrations of heavy metals and TDI. The latter and any surplus chemicals such as acids or alkalies require special disposal methods. These tend to arise from the operations of research and development laboratories more than from production areas.

- Noise

Problems of neighbourhood noise are not likely to be greater than those of comparable industries, and are usually amenable to local solution.

The Working Environment

The working environment in rubber processing has been the subject of numerous studies, and at this time major investigational programmes are being undertaken in several countries. The physical factors of heat and noise may be significant but are amenable to assessment and control. Standards for both have been established and methods for their control are available. Emphasis at this time should be placed on the specification of required conditions.

The chemical environment has been the subject of the most active investigation as the toxicity of a number of the additives used in the processes has lead to ill-effects. The toxicology of the many substances used is too extensive to present here, but has been reviewed in depth by McCormick (Rubb. Chem. Technol, 45, 512-533 and 627-637, 1971). Many epidemiological studies have been reported, the most recent being on occupational cancer in the rubber industry and in cable making in the U.K. (Fox, Lindars, and Owen, Brit. J. Indust. Med., 1974 31, 140-151).

Probably the most significant environmental health problem arises from the cancer potential of some of the additives used in processing. The high risk of bladder cancer arising from the absorption of β-naphthylamine is now recognized; its use and manufacture has been banned in more than one country, and its concentration in other anti-oxidants is strictly controlled. Some materials have been banned on the basis of animal tests rather than evidence of effects in humans, and some materials have been eliminated due to simple suspicion of their chemical form. Practices vary from one country to another and from one plant to another within a single country. For example phenyl β-naphthylamine has been eliminated in some plants-perhaps because it sounds similar to β-naphthylamine. MOCA and ethylene thiourea (suspected to have greater teratogenic activity than carcinogenic) are not used in some plants, and MDI and HDI have completely replaced the more volatile TDI in some locations. Although carbon black is known to contain carcinogenic compounds, industrial experience has shown no evidence of carcinogenicity. Similarly, aromatic rubber extender oils which have shown cancer activity in animal experiments have not been found to produce cancer in workers. This may be because skin contact is minimal in the processes in which such oils are used; there is however suspicion that hot fumes from aromatic oils might be responsible for an increased incidence of lung cancer.

Intensive screening of such compounds is now undertaken in a number of countries, and approval must be given before new materials are introduced.

Mineral dusts have also been responsible for lung damage in processing operations. In particular, asbestos is responsible for lung diseases and for cancer of the chest; it must therefore be strictly controlled in the working environment. Talc dust can also produce serious lung impairment and may require control by exhaust ventilation. The amorphous silica dust used in some operations is far less hazardous than free-silica of quartz or cristabolite but may require control to reduce nuisance and because the toxicity is not absolutely known. Precautions may also be needed in the handling of zinc oxide,not because of its basic toxicity but because heavy metals, particularly lead, may be present though these may be restricted by process requirements.

Operations involving the use of lead require special precautions, and are subject to regulation in most countries. Lead may be used in lead-filled compounds and as formers in the manufacture of certain types of hose.

Amines are potent skin sensiters and contact should be avoided; they may also interfore with vision and damage the eyes. Problems of TDI handling have already been referred to, but must again be stressed here. Absolutely no personal contact can be permitted and special procedures are required to clean up any spilt material.

A wide range of solvents are encountered in the process industry, but generally the most toxic, benzene and carbon tetrachloride, have been banned. Carbon disulphide is still required for some golf-ball manufacture but its use is strictly controlled. For most applications petroleum white spirit can be use; generally this presents little hazard other than its flammability, though it can damage the skin after polonged or frequent contact. Occupational dermatitis is probably the most widespread industrial disease in this industry and requires the introduction of improved controls, based on reduction of skin contact and improved personal hygiene supported by adequate washing facilities.

<u>Suggested Ventilation Practice for the Control of the Working Environment and Air Pollution</u>

Operation	Exhaust	Filtration
Banbury and general mixing	yes	yes
Talc usage	yes	yes
Asbestos operations	yes	yes
Grinding (including retreading)	yes	yes
Moulding and extrusion	yes	no
Latex foaming	yes	no
Glove dipping	yes	no
Golf-ball manufacture (CS_2)	yes	no

Exhaust systems my be required to control the thermal environment as well as toxic substances, and in some countries air conditioning may be required.

THE USE OF RUBBER PRODUCTS

The most widely recognized problem arising from the use of rubber products is that of skin sensitization and dermatitis. This arises from the additives employed rather than the rubber itself.

Recently the introduction of many foamed products into homes, offices, and public buildings, has given rise to serious problems of smoke and other toxic products of pyrolysis in fire incidents, as these have led to increased casualty rates. Active research is being undertaken and codes of practice prepared; the use of flame retardants is being examined but these may increase the toxicity of the fumes generated. Similar studies are being made on transport vehicles, particularly aircraft.

Some recent studies have been made on the effects of tyre wear on the environment and have produced no evidence of potential hazard, though more definitive studies appear to be required. It has been estimated that the rate of tyre wear in the U.S.A. represents about twice the weight of particulate emissions from motor vehicles, but first studies indicate that not all the worn material becomes airborne.

THE RECLAIM INDUSTRY

The reclaim industry is highly dependent on the economic situation both national and international. The principal feedstock for the industry is worn tyres which are generally abundant in developed countries, but which in developing countries tend to find secondary uses. Reclaim becomes economically attractive when the price of virgin rubber is high, but the fluctuation in demand creates problems of capital investment in process plant and in environmental control systems. Reference should also be made to the intermediate industry of tyre retreading which presents environmental problems on a relatively minor scale, principally those of dust and noise control, but which is very activo at the present time. A markot has been found for the buffings from the process in the manufacture of surfaces for sports areas.

The Public Environment - Air Pollution

Reclaim is generally initiated by reducing the scrap to a crumb, and this process may be accompanied by the generation of dust which may need the installation of an air cleaning system on the discharge to atmosphere. Some processes carry a strong risk of generating objectionable odours, and these may need to be controlled by incineration or a scrubber. Extensive use may also be made of hydrocarbon solvents which may require provision of a vapour recovery system.

- Water Pollution

Considerable quantities of water are used in some processes and waste water may contain considerablo quantities of suspended rubber from grinding operations which will create a high BOD/COD. Acids, alkalies, oxidizing and peptising agents may all reach the sewers, and need monitoring and control. Hydrocarbons may be present from minor leakages, and serious accidental releases are possible. As a minimum, some form of simple separator is required to skim off any light fraction. In some processes large quantities of steam are required so waste water is likely to contain water treatment chemicals from boiler blow-down.

- Land Contamination

Land contamination appears to be less likely than in other parts of the rubber industry. Product that cannot be sold can probably be used as land fill, though there may be occasions when undersirable substances (e.g. waste solvents) have to be disposed of. This is probably best done by incineration provided attention is given to smoke control; chlorinated solvents give rise to special disposal problems.

The Reclaim Industry - The Work Environment

The physical problems of noise and heat are likely to require investigation and control, and the first may give rise to neighbourhood problems. Inhalation of talc or other mineral dust used to treat the product may need control by exhaust ventilation. Some peptisers are toxic and have an objectionable odour so require control, and risks may arise from the inhalation of hydrocabon solvents. These may be reduced by proper selection of products used but may also require ventilation control. Entry into confined spaces will require proper safety equipment and procedures.

The alkalies and acids used in the process will require the use of appropriate personal protection to prevent risk to eyes and skin of operators.

THE DISPOSAL OF RUBBER PRODUCTS

The ultimate disposal of rubber articles is more likely to produce aesthetic than toxic problems. The great volume of used tyres finds only partial reuse or reclaim, and ultimately requires disposal. Economic methods depend on local and other conditions. An environmentally desirable method may be grinding and use as a soil conditioner or fertilizer, but the market is limited. Successful experimental construction of fish reefs has been reported but appears to be of limited application due to transport costs. Used tyres are commonly used as land-fill, for which some processing is required to reduce the harbouring of vermin in the voids within the carcase of the tyre. It has been pointed that this practice represents a waste of energy as tyres and other waste rubber products have a significant calorific value. Controlled burning and recovery of the heat is perhaps the best method of disposal, and economically may best be associated with a reclaim plant as a source of heat for the processes. Some highly successful incinerators are in operation, and produce no significant ill-effects on their environment. Control of smoke emission can be achieved by an afterburner controlled by a smoke detection unit and sulphur dioxide concentrations at ground level are controlled by proper selection of stack height, aided by some absorption in the ash collected from the units. The ash may be recoverable, but is more likely to be used as landfill when mixed with other materials for disposal.

An unusual environmental problem has been reported in coastal waters near communities which discharge untreated sewage direct into the sea. Young fish become trapped behind the gills by partially disintegrated contraceptive sheathes, and subsequently become seriously disfigured as they grow within the rubber ring. The aesthetic problem presented at the dining table is the best controlled by requiring the treatment of all sewage before discharge to the general environment.

AIR POLLUTION CRITERIA

There are no air pollution criteria specific to the rubber industry, but compliance is generally required with local or national standards set for industrial and domestic air pollution sources.

The principal source of guidance to internationally accepted standards is the Report of a WHO Expert Committee on Air Quality Criteria and Guides for Urban Air Pollutants (WHO Tech. Rep Series 506, Geneva,1972). This is primarily concerned with the control of human health by direct inhalation of pollutant, rather than damage to vegetation, or to other effects of ground contamination such as the ingestion of heavy metals by grazing anumals, which may require more restrictive standards.

The Committee stress that the following tabulated results should not be considered independently of the accompanying text ; before decision making based on these criteria the report must be consulted.

RECOMMENDATIONS LONG-TERM GOALS

Pollutant and measurement method		Limiting level
Sulphur oxides - British Standard Method	Annual mean	60 μg/m^3
	98% observations below	200 μg/m^3
Suspended particulates - British Standard Method	Annual mean	40 μg/m^3
	98% observations below	120 μg/m^3
Carbon monoxide - Nondispersive infrared	8 hour average	10 mg/m^3
	1 hour maximum	40 mg/m^3
Photochemical- Oxidant as measured by neutral buffered KI method expressed as ozone	8 hour average	60 μg/m^3
	1 hour maximum	120 μg/m^3

For other substances the committee did not consider that adequate informati[on] existed for standards to be set. It should however be stressed that numerous national and local criteria exist, and that these may have to be met by individual plants.

With respect to the rubber industry, the most relevant standard is that for sulphur oxides which are likely to be emitted from heating and steam-raising plants. In some locations the emission of oxidants may also need control

Control is achieved by discharging sulphur oxides from stacks of sufficient height to ensure adequate dispersion of the plume before it reaches occupied areas.

A number of formulae have been developed to permit estimation of ground level concentrations of products (including sulphur oxides) from stack discharges. The nearest to an internationally accepted method is that published by CONCAWE (The Calculation of Atmospheric Dispersion from a Stack, Stichting CONCAWE, The Hague, 1966). From the USA there is available a useful Recommended Guide for the Prediction of the Dispersion of Airborne Effluents (Am.Soc.Mech. Engineers, New York, 1968), and the UK government publishes "Chimney Heights", a Clean Air Act memorandum (HMSO London, 2nd Edition, 1967)

WATER POLLUTION CRITERIA

A useful guide to the quality of water used for various purposes (from UNIDO-UNEP Case Study on the Textile Industry of Thailand, Marstrand et al, University of Sussex) is shown below:

Controlling Water Use	Stream Standard: Quality Parameter	Stream Standard: Suggested Level
Potable water supply	Most probable number of coliforms (MPN)	Effluent quality similar to the natural state of surface water.
	pH	6.5-8.5
	Dissolved oxygen	greater than 2 mg/l
	Arsenic	less than 0.05 mg/l
	Lead	less than 0.05 mg/l
	Chromium (hexavalent)	less than 0.05 mg/l
	Cyanide	less than 0.2 mg/l
	Phenolic substances	less than 0.002 mg/l
	Chlorides	less than 1,000 mg/l
	Total dissolved solids	less than 4,000 mg/l
Irrigation	Total dissolved solids (TDS)	Not more than 400 mg/l where there is poor drainage, saline soil and inadequate water supply. (EC less than 0.75 millimhos per $^{\circ}$cm. at 25°C.) Not more than 1,000 mg/l where there is good drainage and proper irrigation management. (EC less than 1.75 millimhos per $^{\circ}$cm. at 25°C. Not more than 2,000 mg/l where there are salt-resistant crops, good drainage, proper water management and low sodium adsorption ratio (SAR) of water. (EC less than 2.25 millimhos per cm. at 25°C.)
	Sodium absorption ratio (SAR)	Not more than 10 where there is poor drainage. Not more than 18 where there is good drainage.
	Boron	Not more than 1.25 mg/l where there are sensitive crops. Not more than 4 mg/l where there are tolerant crops.
	Dissolved oxygen	Greater than 2 mg/l. A level of 2 mg/l should not occur for more than 8 hours out of any 24-hour period

	Pesticides	
	DDT	0.002 mg/l
	Endrin	0.004 mg/l
	B.H.C.	0.21 mg/l
	Methyl Parathion	0.10 mg/l
	Malathion	0.16 mg/l
Fishing	CO_2	12 mg/l
	pH	6.5-8.5
	NH_3	less than 1 mg/l
	Heavy metals	less than 1 mg/l
	Copper	less than 0.02 mg/l
	Arsenic	less than 1 mg/l
	Lead	less than 0.1 mg/l
	Selenium	less than 0.1 mg/l
	Cyanides	less than 0.012 mg/l
	Phenols	less than 0.02 mg/l
	Dissolved solids	less than 1,000 mg/l
	Detergents	less than 0.2 mg/l
Waste Disposal	Dissolved oxygen	Greater than or equal to 0 mg/l

Source : M.B. Pescod, Investigation of Rational Effluent & Stream Standards for tropical countries. Interim Research Report AIT 1973

Where receiving waters are used for drinking purposes the relevant criteria are given in the International Standards for Drinking Water (WHO 1971). Virological biological and radioactive criteria are given, and the bacteriological standard for non-disinfested supplies is that E.Coli should not be present in 100 ml samples, but the occasional presence of up to 3 coliform organisms per 100 ml may be tolerated.

The tentative limits for toxic substances in drinking water are :

Arsenic	0.05 mg/l
Cadmium	0.01 mg/l
Cyanide	0.05 mg/l
Lead	0.1 mg/l
Mercury	0.001 mg/l
Selenium	0.01 mg/l

Pesticide levels are continuously under review by a joint FAO/WHO meeting and recommended limits for total daily intake of specific substances have been set. It is considered essential that complete knowledge of the fate of pesticides must be known before levels can be set in drinking water.

Limits on specific chemical substances that may affect health include those for fluorides (lower limit 0.6–0.9 mg/l, upper limit 0.8-1.7 mg/l, dependent on temperature), nitrates (not more than 45 mg/l), nitites (there is a possibility of forming carcinogenic nitrosamines) and polynuclear aromatic hydrocarbons (limit for six representative compounds not greater than 0.2 µg/l).

A table of substances and characteristics that affect the acceptability of water for domestic use include :

	Highest Desirable	Max. Permissible
Suspended matter	5 turbidity units	25 turbidity units
Total solids	500 mg/l	1500 mg/l
pH range	7.0–8.5	6.5– 9.2
Anionic detergents	0.2 mg/l	1.0 mg/l
Mineral oil	0.01 mg/l	0.30 mg/l
Phenolic compounds	0.001 mg/l	0.002 mg/l
Calcium	75 mg/l	200 mg/l
Chloride	200 mg/l	600 mg/l
Copper	0.05 mg/l	1.5 mg/l
Iron	0.1 mg/l	1.0 mg/l
Magnesium, if sulphate>250 mg/l if sulphate<250 mg/l	30 mg/l 150 mg/l	150 mg/l
Manganese	0.05 mg/l	0.5 mg/l
Sulphite	200 mg/l	400 mg/l
Zinc	5.0 mg/l	15 mg/l

Where receiving waters are not used for drinking, other criteria must be used to assess the acceptability of given levels of waste discharge. The values will depend on both the substances discharged, and the use to which the water is put - supply for domestic animals, irrigation, recreation, etc - as well as baseline requirements to protect the general ecology of the acquatic environment such as the avoidance of eutrophication and foaming. Data are available from a number of publications and each plant or process area should be separately assessed as a contributing source of pollution.

As an example of general limits, in England and Wales discharges to surface water are likely to be restricted to 20 mg/l BOD and 30 mg/l suspended solids, though this may be varied to meet specific needs to guard drinking water supplies, industrial uses, fish or other acquatic life. Discharge of some metals to surface water would probably be limited to 0.05 mg/l and in sewage to a treatment plant, 1 mg/l.

In the United Sates, a rather different approach has been made by the

Environmental Protection Agency. Rather than vary the standard with the need of the receiving water, standards are proposed which are based on best practicable and best available treatment technology. The quantities (rather than the concentration) of waste effluent are then related to the production throughput of the plant.

The information below is taken from the EPA Effluent Guidelines and Standards, Rubber Processing and Rubber Manufacturing, Point Source Category, Federal Register, 39,36 Feb.21,1974 (pp 6661-6667).

Tyre and inner tube plants	Standards for best practicable control technology, best available technology economically achievable and for new sources	
	Maximum for any 1 day	Maximum for daily average over 30 days
	kg/tonne product	
Total suspended solids	0.096	0.064
Oil and grease	0.024	0.016
pH	6.0-9.0	

Emulsion crumb rubber	Best practicable control technology		Best available technology economically achievable	
	Maximum for any 1 day	Maximum for daily average over 30 days	Max.for any 1 day	Max.daily averg. over 30 days
	kg/tonne product			
COD	12.00	8.00	3.12	2.08
BOD_5	0.60	0.40	0.12	0.08
Total SS	0.98	0.65	0.24	0.16
Oil and grease	0.24	0.16	0.12	0.08
pH	within the range 6.0 to 9.0			
Solution crumb rubber				
COD	5.91	3.94	3.12	2.08
BOD_5	0.60	0.40	0.12	0.08
Total SS	0.98	0.65	0.24	0.16
Oil and grease	0.24	0.16	0.12	0.08
pH	within the range 6.0 to 9.0			
Latex rubber				
COD	10.27	6.85	2.66	1.78
BOD_5	0.51	0.34	0.11	0.07
Total SS	0.82	0.55	0.21	0.14
Oil and grease	0.21	0.14	0.11	0.07
pH	within the range 6.0 to 9.0			

The EPA approach appears to be based on placing equal obligations on all plants rather than enforcing the strictest controls where the environment is most vulnerable. This contrasts with the approach in some other countries, and the choice seems to be governed solely by economic considerations.

Methods of Controlling Discharge of Liquid Effluents.

For high capital investment plants for the manufacture of synthetic rubber, a series of treatment steps are usually undertaken.

An initial wedge wire screen installation has been found to reduce suspende solids from 500 mg/l to 100 mg/l at one manufacturing plant. Subsequent treatment by coagulation and air flotation has reduced the discharge concentrati to 30 mg/l in a flow of about 500 m^3/hr , and is considered acceptable for discharge to the sea by pipeline.

A latex manufacturing plant discharging to esturial waters uses only a coagulation and flocculation process (with pH control), followed by holding in a series of ponds. After the treated process water is blended into the main cooling water discharge, no difficulty is found in meeting the standards required by the local authority, which are 25 mg/l BOD and 30 mg/l suspended solids. No pollution problems have been recognized in the environment from this discharge.

An inland plant processing latex has found no problem in limiting storm water (rain run-off) to a 10 mg/l BOD requirement, but limits for discharges to sewers required by the community treatment plant of 400 mg/l suspended solids and 500 mg/l COD cannot be met without installing on-site treatment facilities.

In another example reported from the United States, the installation of a secondary waste water treatment plant at a synthetic rubber factory led to a reported overall reduction of suspended solids by 85% and BOD_5 by 84%. Initial concentrations were 72 mg/l and 197 mg/l respectively, with a COD of 447 mg/l. The total project cost was reported to be about $ 2 million (U.S.EPA 660/ 2-7-018,1973).

The following table shows some reported typical values (Environmental Protection in the Synthetic Rubber Industry, U.S. National Industrial Pollution Control Council, 1973).

	Untreated	Treated for stream	Treated for sewer
BOD	300 ppm	10 ppm	200 ppm
COD	200-2000 ppm	200 ppm	
Suspended solids	400-1500 ppm	15 ppm	300 ppm

This report summarises water treatment needs thus :

" Restrictions are placed on waste water for acidity, alkalinity, colour, odour, temperature, nitrogen content, dissolved solids, hydrocarbon content, heavy metals, toxicity, free and emulsified oil, dissolved oxygen, ammonia, phenols and refractory materials."

CRITERIA FOR NOISE EVALUATION

There are three principal reasons for controlling noise, these are :

1. to prevent damage to hearing
2. to avoid interference with speech communication
3. to limit annoyance to people living nearby

Damage to hearing is likely to occur where workers are exposed to high noise levels for long periods. It is generally accepted that the noise limit for an 8 hour working day is about 90 dBA and that exposure time should be halved for each step of 3 or 5 dBA above that level.

A committee of the International Standards Office has published a recommendation "Assessment of Occupational Noise Exposure for Hearing Conservation Purposes", R.1999, 1971, on this subject. This relates noise exposure to the proportion of workers likely to suffer significant hearing loss, and forms the basis by which national authorities can set standards corresponding to what is considered an acceptable level of harm.

The need to control speech communication interference is largely a technical matter for management; a variety of standards has been proposed by a number of authors for different situations (eg. offices, control rooms, etc).

The control of neighbourhood noise is the aspect most likely to incur significant cost, as noise control installations for existing plant can prove expensive. Standards for assessing likely annoyance have been successfully applied in the UK for some years (Method of Rating Industrial Noise Affecting Mixed Residential and Industrial Areas, BS 4142,1967). An expert committee of the International Standards Organization have published a similar procedure (Assessment of Noise with Respect to Community Response, R.1996, 1971), though it suggests a likely range for acceptable base levels, and leaves national authorities to set the appropriate limit for the particular community.

Noise control is best effected by the application of established procedures for specifying noise levels in new contracts (UK Oil Companies Materials Association, Procedural Specification for Limitation of Noise in Plant and Equipment for Use in the Petroleum Industry) and by incorporating noise considerations in all new design work.

Many of today's problems arise simply because no attention was given to noise aspects in baic design, as exemplified by the absence of mufflers on air compressor intakes, or the location of noise generating equipment on site boundaries near living areas.

A RANDOM BIBLIOGRAPHY ON THE ENVIRONMENTAL IMPACT OF THE RUBBER INDUSTRY

The following references have been obtained as a result of an unsystematic search, for data over a 6-week period. They represent only a proportion of the published literature and generally comprise recent references. Classical earlier work, particularly on occupational hazards, can be traced from the references given in the cited papers.

The references are broadly classified by area of principal concern: General environmental control and hazards in rubber use, air pollution, water pollution, reclaim and disposal, and occupational hazards.

Abstracts are those of the author, cited by Chem. Abstracts or Index Medicus, or prepared for this bibliography.

GENERAL ENVIRONMENTAL CONTROL AND HAZARDS IN RUBBER USE

Environmental Control in the Manufacture of Carbon Black, F. Rowe Jnr. (Phillips Petroleum). Paper No. 30, Am. Chem. Society, Division of Rubber Chemistry, Toronto, 1974.

Describes improvements made in air pollution control equipment in the United States. It gives no numerical information on environmental improvement achieved and makes only passing reference to water pollution. With illustrations but no references.

Environmental Protection in the Synthetic Rubber Industry, U.S. National Industrial Pollution Control Council, 1973.

A public relations review with some useful items of information, for example a single U.S. company produces about 0.6 million tonnes synthetic rubber per year, creating about 6000tonnes per year of solid waste and about 6.5 million cub. metre of liquid effluent.

Typical pollution indices for the liquid effluent are:

	Raw effluent mg/l	Treated for discharge to surface wastes mg/l	sewers mg/l
BOD	300	10	200
COD	200–2000	200	-
suspended solids	400–1500	15	300

Simplified process flow diagrams are given; environmental problems and the necessary control equipment are described.

Handling and Processing of Carbon Black without Pollution, O.K.F. Bussemaker, Symposium Proceedings, Rubber and Environment Sveriges Gummitekniska Förenings Årsmöt i Tylösand, 1972. SGF Pub. 39.

Describes mechanical handling methods to minimize environmental contamination by carbon black in manufacture and use.

Testing of du Pont Rubber Chemicals for Health Hazards, P.R. Johnson, ibid.

Includes a figure showing that the number of publications dealing with specific toxicity questions rose from 18 in 1940-44 to 53 in 1960-64.

Fire Hazards of Plastics in Furniture and Furnishings; Ignition Studies, K.N. Palmer and W. Taylor U.K. Building Research Establishment current paper CP 18/74.

This includes ignition tests on rubber latex foam, bare and fabric covered which isshown to ignite more readily than polyether foam. Toxic products of combustion are not consibred here.

Toxic Pyrolysis (Thermal degradation) products of resins and polymers. Brunner H. Report No. PVM/191/B/72-73. Paints Division, ICI Ltd., October 1972.

Environmental problems with rubber manufacturing; S. Olsson, SGF (Sver. Gummitek Foesen) Pub. 1972, No. 39, I, 21 (Swedish) Methodsof maintaining clean oil and water as well as proper noise levels while handling dangerous solvents, lead compounds, talc dust and other accelerators and stabilizers are described.

Regeneration of plastics by micro-organisms, Isoue, M. Plast. Ind. News 1973 19(2) 17-26 (English). Degradation of plastics by micro-organisms as a method of waste disposal was discussed. Moulds were worn on silicone resin, glass fibre reinforced epoxy composite, PVC, nylon and polyurethane resin which have been listed as mould proof by MIL-STD 454B.

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Health-chemical study of the gases generated by several rubbers. Gorshunova A.I., Gig.Tr.Prof.Zabol, 1972, 16:58-60 (in Russian)

Hygienic Significance of some measures aimed for the improvement of technology of the SKMG rubber production. Dvorianinova, H.K., Gig.Tr.Prof.Zabol, 1972, 16:33-5 (in Russian)

Contact-dermatitis caused by rubber chemicals in dairy workers. Lintum, J.C., Berufsdermatosen, 1973, 21:16-22

Technical progress and means of improvement of labour conditions in the production of rubber articles. Bagdinov, I.M., Gig. Sanit, 1973, 38:25-9 (in Russian, with English Abstract)

Volatiles evolved from polymeric structural materials III. Polystyrene and polyurethane foams and porous materials, Yablochkin, V.D., Schirskaya, V.A. Popov, A.M., Gorshunova, A.I., Kolchina, E.V., Checkn, E.I., Actual.Vop.Korm. Biol.Med. 1971, 301-5.

Polyurethane insulating foams do not decompose at room temperature and do not evolve toxic gases but at high temperatures (100-200°C) decompose to give tolylylene diisocyanate, CO, CO_2, N oxides and even HCN (at 200). Expanded polystyrene gives off PhCH:CH_2, solvents, PhEt, CO, CO_2, and hydrocarbons at room temperature. When temperature is raised, gas evolution increases rapidly.

Gas Evolution from Polymeric Materials during Storage, Gorshumova A.I. Checkno, E., Aktual. Vop. Kosm. Biol. Med. 1971, 89-93.

The evolution of gases from stable polymeric materials (siloxane rubber gaskets, chloroprene rubber binder, epoxy resin binder) decreases exponentially during aging, $Ct = Coe^{-at}$. When a piece of aged material such as a porous insulating panel is cut, evolution of gas is increased. When a material starts cracking due to ageing, the gas evolution rate also increases. (in Russian)

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Eczematous lesions due to the hypersensitivity to components of rubbers, Budar S., Przegl Derm., 1970, 57,489-495 (in Polish)

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Hygienic studies of resins intended for contact with food products, Shumskaia, Gig.Sanit.38, 1973, 28-30. (in Russian)

Eczema caused by rubber, Sailo, F. et al, Jap.J. Dermatol (A),1972, 82, 763-772.

Sanitary-hygienic assessment of shoes made of synthetic polymers, Sautin,A.I., Kaznina, N.I.,Es'kova-Soskovets, L.B. Gig.Sanit, 1972, 11,60-3. The synthetic polymers SK and kozhvolon in glues KP-33 and NT released dimethylformamide, styrene, butanediol and severe toxic compounds at moderate to warm temperatures. Therefore shoes should not be made from these materials.

Continuously removing volatile hydrocarbons from an elastomer, Johnson,C.R., Moosavian, S.H., South African Pat App.7105,617, 23 March 1972. US App. 69,806, 4 Sept. 1970. A process was described for the continuous removal of volatile hydrocarbons from rubbers. Thus, nitrogen was added to butadiene rubber and bsr that were mechanically worked in an extruder to raise their temperature and volatile hydrocarbons (eg pentane and hexane) were flashed from the mixture.

AIR POLLUTION

Particle size Determination of Tire Tread Rubber in Atmospheric Dusts, J.A.Cardina. Paper 24, Ecology Symposium Am.Chem Soc. Division of Rubber Chemistry, Toronto, May, 1974.

An Anderson Hi-vol impactor was used within 20 feet of heavy traffic. It indicated that 25-40 % of rubber particles (identified by pyrolysis gas chromatography) were in the respirable range-taken to be 1-7 µm diameter unit-density spheres. In this size range, mass concentrations of rubber particles varied from 1.0 to 4.9 $\mu g/m^3$ and represented 1.5-9.2% of total airborne dust. No checks on stage blow-off appear to have been made.

Airborne Particulate Debris from Rubber Tires, W.R. Pierson and W.W. Brachaczek, Paper 23, ibid.

Air samples were taken within vehicle tunnels and compared with those at air intakes, the sampling techniques are only described indirectly (glass fibre and membrane filters in Hi-vol samplers). They conclude that airborne tire dust in urban areas is of the order of 1 $\mu g/m^3$ and about 1% of total dust, corresponding to 5-45% of airborne exhaust particles. Perhaps only 5-10% of total tire dust wear becomes airborne particles. (They noted that diesel exhaust caused filter paper plugging, presumably due to the smoke).

Tire Dust from Normal Wear of Tires, M.L.Dannis, Paper 25, ibid.

Samples were collected close to the tires of vehicles on the road by an unproven technique; discussion is lengthy and difficult to follow. It appears to present little new information though numerous log-normal size distributions are reported.

Carbon Black Plant Sends Air Pollution Packing, Anon, Chem Week, Nov 15, 1972, 55-6.

A "popular" review of one plant's clean-up programme.

Odours- Part I, Assessment of the Problem in Gt.Britain, Report of the Working Party on the Suppression of Odours from Offensive and Selected Other Trades, UK Warren Spring Laboratory, 1974.

Out of about 100 cases from miscellaneous industries that have been studied by local authorities a maximum of 11 are from the rubber industry. Three are from rubber processing, one from tyre moulding, four from carpet backing, two fro resin bonding, and one from cable burning. It is evident that the rubber industry is not a major source of odour complaints, which totalled about 1000 in the period reviewed.

Catalytic Purification of Gases Evolved in the Synthetic Butadiene Rubber Industry II, Alanova, T.G., Myagkova, A.A., Orlova, L.N. Prom. Sin. Kauch., Nauch.-Tekh. Sb.,1971, 11, 6-8.

The activity of different catalysts in the oxidation of separate components of evolved gases and their mixtures (aromatic, dimer, butadiene-vinylcyclohexene, trimer butadiene-cyclododecatriene) was studied. The dependence of log rate constant of oxidation of aromatic compounds on 1/T for different catalysts is given. The activation energy of the reaction on Pt/Ni-Cr is 19, on Al-Pt contact reformer AP_{reg} 16 and on Mn-ore 13 kcal/mole. (in Russian)

WATER POLLUTION

U.S. Environmental Protection Agency, Effluent Guidelines and Standards, Part 428 Rubber Processing Point Source Category, Rubber Manufacturing Point Source Category, U.S. Federal Register 39, 36. Feb. 21, 1974. These rules stipulate the standard that industrial plants in the USA must meet by July 1977 on the basis of best practicable technology and by July 1983 on the basis of best achievable technology. Comments received on earlier proposals and their modification are included.

Development Document for Proposed Effluent Limitation Guidelines and New Source Performance Standards for the Tire and Synthetic Segment of the Rubber Processing Point Source Category, U.S. Env. Prot. Agency EPA-AAO/1-73/013, 1973.

A very detailed (about 200 pages) document giving all data collected to form a basis for U.S. legislation. This must be the standard reference source for developed countries. Conclusions and recommendations cover about 4 pages. The main controversial assumption is relating effluent quantities to production based on ability to clean-up waste water rather than to meet local environmental needs.

Economic Analysis of Proposed Effluent Guidlines, The Rubber Processing Industry, U.S. Env. Prot. Agency, EPA-230/1-73-024, 1973.

This is not an official EPA publication but is a contract report prepared by Arthur D. Little Inc. for EPA. It is much less definitive than the Development Document and makes numerous assumptions in deriving investment and annual operating costs. There are probably only relevant to domestic U.S. operations.

Air Flotation - Biological oxidation of Synthetic Rubber and latex Wastewater. U.S. Env. Port. Agency, EPA-680/2-73-018, 1973.

Also presented as paper by F.G. Troppe (Firestone Tyre and Rubber) Secondary Treatment of Wastewater from Synthetic Rubber Production, Ecology Symposium, Am. Chem. Society, Rubber Division Meeting, Toronto, 1974.

This must be a standard reference for the engineering control of waste water as it is a thorough study of the effectiveness of a individdency wastewater treatment system which includes neutralization, coagulation and flocculation, primary clarification, biological treatment, final clarification and sludge impoundment. Clarification is by disolved air flotation and biological treatment is by completely mixed aerated lagoon. Handles 3.5 million gallons per day, containing salt dilute acid wastes, boiler water blowdown, dilute latex and coagulated rubber solids. BODs was reduced from 72 mg/l to 11, COD from 447 mg/l to 73 mg/l, and suspended solids from 197 mg/l to 29 mg/l. The total project cost was about $ 2 million or $0.50 per 1000 gallons treated. Very comprehensive analyses have been made for trace metals and other pollutants and arepresented in numerous tables showing concetrations at each treatment stage.

Treatment of Special Industrial Wastes, D.H. Sharpe, Civil Engineering, June 1961, 56, 801-804.
This includes a description of treatment plant for water effluent from a lactron (latex) thread manufacturing plant. Acid effluent is simply neutralized with ammonia or lime solution but alkaline wastes cont minated with latex are first treated with aluminium sulphate, settled, skimmed (skimmings are adsorbed on coke and burned), then percolated through wood shaving beds before discharge. Used shavings are also burned.

Purification of Waste Water in the Production of Carbon Black.M.I. Ass., G.V. Kolomeitsev and I.S. Belova, Soviet Rubber Technology 23, 5 May 1964. This provides details of a water treatment installation of a single plant. The principal source is the foaming apparatus for final purification of gas before combustion-up to 7300 mg/l sulphates and 135 mg/l hydrogen sulphide. Waste water is recirculated and information given on treatment methods and results. Coagulation by 50 mg/l $Al_2(SO_4)_3$+200 mg/l $Ca(OH)_2$ was found most satisfactory and many experiments are described.

Stabilization Pond Design Criteria for Tropical Asia, M.G. McGarry and M.B. Pescod, Asian Institute of Technology, Bangkok, Thailand.

Although this paper is principally concerned with treatment of domestic sewage, the system described appears emminently suitable for treating water effluents from natural rubber production.

Disposal of Factory Effluents from Crepe and Sheet Production Factories, K.F. Heinisch and M. Nadavajak, Quarterly Journal Rubber Research Institute of Ceylon, 1963, 39, 32-37.
Briefly describes typical liquid effluents from natural rubber producing factories. It suggests separation of process and cooling water, and describes the installation of experimental covered tanks comprising a primary settling chamber, limestone bed for neutralization and secondary settling chamber. One of these reduced BOD from 294 mg/l to 115 mg/l at a cost of RS.1500. Studies are being continued.

Re-use facility rehabilitation.
Kaye, J.B. J. Am. Wat. Wks Ass., 1971, 63, 641-643.

Wash waters from manufacture of latexes treated with alum, neutralized settled in lagoons and re-used. Rubber deposits dredged from lagoons after several years operation.

Microbial purification of some specific industrial wastes.
8. Treatment of petrochemical wastes (1).
Mikami, E. et al. Rep. Ferment. Res. Inst., 1968, No. 33, 41-49; Biol. Abstr., 1970, 51, 1544.

Use of activated-sludge process for the treatment of waste waters from production of latex showed that the maximal COD loading was 1.5 kg/m^{3}d; adjustment of the pH value to 8-9 and addition of inorganic nutrients were necessary.

Purification of sewage contaminated with latex. Mokrzycki, J. et al. Pr. Inst. Wlok., 1963, 13, 149-162. Chem. Abstr., 1966, 64, 3192.
Best coagulants for treating waste waters were aluminium sulphate (350 mg/l) and iron salts (ferrous sulphate -250 mg/l). COD was reduced by 87-98% and the BOD by 84-87%.

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The treatment of aqueous effluent from rubber production using a trickling filter.
Molesworth, T.V. Proc. nat. Rubber Res. Conf., Kuala Lumpur, 1960, 944-959.

Description of coagulation of diluted skim serum from rubber processing wastes with ferric chloride and lime, then aeration, settlement and biological filtration through a granite filter.

Pre-treatment of latex rubber waste.
Jennings, A. J. Inst. Sew. Purif., 1955, Pt 1, 85.

Description of experiments using coagulation by sulphuric acid (200 mg/l) and flotation to pre-treat waste waters containing rubber.

Toxicity of wastes from the manufacture of synthetic rubber. Zelinka M., (Voda, 36, 242, 1957). Chem. Abstr., 54, 10193c, 1960.

Wastes from the manuf. of synthetic rubber contain various org. compds. which are toxic to certain organisms present in surface water The following limits of toxicity are reported in mg./l.: crotonaldehyde 0.5, styrene 10, nekal 20-5, and AcH 25. From C.Z. 1958, 6064.

The possibility of the electro chemical destruction of some ingredients of the waste water from industrial organic synthesis. Ivanov, V.A., and Makrinov, V.A. Biol. Abstr., 1969, 50, 9636.

Laboratory studies have shown that electrolysis will decompose Nekal in waste waters from synthetic-rubber factories.

Treatment of waste waters from the manufacture of synthetic rubber, Munteanu, A., et al. Studii Prot. Epur. Apel., Buc., 1967, 9, 123-163.

Treatment at a Romanian factory is described which includes aeration to remove volatile substance, equalization, and sedimentation, treatment in high-rate aerated percolating filters at 0.5-1.0 m^3/m^3 and 0.3-0.5 kg BOD/m^3d. Addition of domestic sewage was unnecessary provided that phosphorus was supplied in doses of 3-5 mg/l. 70 per cent of the BOD was removed (design 95 per cent) owing to oversizing of the filters and insufficient aeration. Copper was present and was possibly inhibitory.

Purification of waste water in the production of carbon black. Ass, M.I., Kolomeitsev, G.V., and Belova, I.S. Soviet Rubb. Technol., 1965, 23, No. 8, 46-47; J. appl. chem. Abstr., 1966, 16, i-100.

Neutralization by lime and coagulation by aluminium sulphate for removal of carbon black from waste waters 450 mg suspended matter reduced to 72 per cent, 1500-200 mg/l reduced 94 per cent.

Integrated system for plant wastes combats stream pollution. Montgomery, D.R. Chem. Engng, Albany, 1967, 74, No. 5 108-110.

Description of plant at Goodrich-Gulf Chemicals Inc., Va. for treatment of waste waters from the manufacture of styrene-butadiene rubber and cis-polybutadiene production. Treatment includes passage through crumb pits, neutralization, skimming and biological treatment by activated sludge. Ammonia and phosphoric are added as nutrients. Biological plant removes 90 per cent of the BOD.

Purification of sewage contaminated with latex, Morzycki, J. et al Chem. Abstr., 1966, 64, 3192.

Coagulation of waste waters containing natural and synthetic latexes by coagulation using aluminium sulphate (350 mg/l) and ferrous sulphate (250 mg/l). The BOD and COD of the waste waters were reduced between 84 and 87 per cent and 87 and 98 per cent respectively.

Clarification of waste waters from the production of polysulphide rubbers. Ivanov, V.I. Chem. Abstr., 1964, 61, 14345.

Sulphides and sulphites are decomposed by sulphuric acid to form sulphur dioxide, hydrogen sulphide and sodium sulphate. Sulphur dioxide is absorbed into alkali and re-used. After dilution the BOD of the waste waters are reduced 96-9[illegible] per cent by aeration.

Combined method of ion exchange and adsorption for removing Nekal from waste waters. Chem. Abstr., 1965, 62, 12889-12890.

The waste waters were coagulated with aluminium sulphate and polyacrylamide, filtered through a sand-gravel filter, passed through and [illegible] exchange unit containing anionic resin and treated with activated carbon under static conditions. Finally waste waters were treated by a biological process.

Final biological purification of waste waters from SKK-40 rubber finishing shops and sanitation conditions for their discharge, Taradin, Ya. Chem. Abstr., 1965, 62, 11522.

Waste waters treated experimentally by the activated-sludge process after removal of Nekal by ion-exchange and adsorption on activated carbon. Aeration for 8 h. with added nutrients reduced BOD from 47 to 11.8 mg/l and COD from 129 to 25 mg/l.

Use of coagulation and extraction for purifying synthetic rubber production waste waters. Strukov, F.I. Chem. Abstr., 1965, 62, 11522.

Results of experimental treatment using coagulation and solvent extraction for the removal of Nekal and colophony from emulsion rubber finishing waste waters. Coagulant was aluminium sulphate and a coagulant aid-polyacrylamide. Best results for extraction were obtained with a ratio of solvent to water of 1:1. A variety of alcohols were studied for use as solvent.

Waste waters from synthetic rubber works, Schulmann, J. Voda, 1958, 37, 29-30. Chem. Zbl., 1960, 131, 16554.

The composition and constituents of waste waters from synthetic rubber works in various countries are described and an account is given of the process used in Czechoslovakia for the treatment of these waste waters.

Waste waters from the production of synthetic rubber. Water Pollution Research 1969, 129-131.

Short-term biodegradability and toxicity tests on a simulated trade effluent containing principally styrene and polystyrene.

Hygienic Standardization of the Components of thb Sewage from the Manufacture of Rubber in the Water of Reservoirs, Vaisman, I.Ietal, Gig. Sanit. 1973, 12, 17-21 (in Russian).

Hygienic Standardisation of the Components of Waste Water from Rubber Production in Reservoir Water, Y. Vaisman, et al, Gig. Sanit. 1973, 2, 17-21. Data are given for the organoleptic properties of various materials involved in rubber manufacture along with their LD_{50} for mice, rats, and rabbits. For Captax, thiuram E, nitrosophenol and indotoluidine the concentrations which affect a number of physiological tests of toxicity are tabulated. It is recommended that undissolved Captax, Altax, Thiuram D and Thiuram E be absent from waste waters, and that maximum concentrations in mg/l of other substances be as follows: Sulphenamide BT 0.05; dye blue 3 10.0; Brown dye 0.5; thiozol Brown BS 0.5; nitrosophenol 0.015; indotoluidine 1.0.

(in Russian)

Removal of Nekal from 1,3,butadiene-styrene and 1,3,butadiene-nitrile Rubber Production Waste Waters and Regeneration of Nekal. Garobov IM, Mamedor A.4. Azerb.Khim.Zh. 1971, 5-6, 143-5. Industrial effluent containing AlCls from one chemical operation is used to prepare the adsorbent for purifying Nekal-containing waste water from another operation. The effluent is treated with lime milk to reach pH of 11.5-12.0. Then a solution of $AlCl_3$ or $Al_2(SO_4)_3$ is added and the mixture stirred for 10-15 minutes. In order to increase the floc size and settling rate, 4 ppm polyacryl amide is also added. The alumogel formed during a 1 hour decantation period adsorbs about 12 wt.% of Nekal from waste water. Nekal can easily be desorbed by saturated NaCl in aqueous solution and reused. The settled hydrated alumina can be treated with H_2SO_4 containing waste water (from a nearby wood hydrolysis plant) and recovered as $Al_2(SO_4)3$. (in Russian)

Biodegradable Emulsifier for Polychloroprene, N.L. Turner, German Offen. 2,210,957. 30Nov.1972. US Appl.144,226, 17May,1971.

Duponol 80 (Na octyl sulphate) is used as a secondary emulsifior during the emulsion polymerisation of chloroprene with disproportionated rosin as the emulsifier. Duponol 80 is biodegradable and the emulsifier solutions separated from coagulate polychloroprene can be discarded without removing the emulsifier. (in German)

Reclaim and Disposal

A System and Methods Analysis of the Reuse of Consumer Rubber Goods, 1971
Report for Rubber Manufacturer's Ass., New York, by Roy F. Weston Inc.

A computer analysis for the most economic distribution for tyre recovery and processing in the United States. Destructive distillation most favoured at 7 centres, fish reefs at 3 locations.
Asphalt additive and carbon black generally less economic alternatives.
Biggest operating cost is granulation.

Rubber Reuse and Solid Waste Management, Part I. U.S. Env. Protect. Agency, 1971. This report was prepared by R.J. Pettigrew and F.H. Roninger of Uniroyal Chemical relating to conditions in 1968.
120 pages of which 38 represent a bibliography of reclaim publications and chemicals used in the industry. It is a thorough review of the U.S. industry at that time but makes little reference to the environmental problems that may occur or be solved if the recommendations are implemented.

Disposal of Wastes in the Rubber Industry, J.R. Scott, Chemistry and Industry, 1956, p. 31-33.
An excellent review of the problem and possible solutions which demonstrates how little real progress has recently been made.

Problems in Waste Rubber Disposal. W. Hofmann, Paper 26, Ecology Symposium, Am. Chem. Soc., Division of Rubber Chemistry, Toronto, 1974. Reviews possible uses with particular reference to worn tyres and refers to systematic studies in W. Germany including the burning of worn tyres and the leaching of chemicals from dumped tyres. In Germany, 500 large scale tips for domestic refuse are planned, these will accept sliced tyres which will not exceed 1.2% the volume of the total waste. However, 15-20 special tyre tipping grounds are also proposed but disposal cost will be higher even if there were as many as 50 such sites. Recycling is considered in some detail. 230 publications are cited.

Used Tyre Disposal in Britain. J. Brotherton and K. Roberts, Royal Institute of Public Administration C177 September 1973.

The severity of this problem varies from region to region and is principally due to lack of tipping sites. Recycling has not been fully evaluated and U.K. reclaim industry is in crisis through lack of capital investment.

Scrap Tires as Artificial Reefs, R.B. Stone, C.C. Buchanan, F.W. Steimle Jr., U.S. Environmental Protection Agency, 1974.

The study shows that fish reefs can be constructed at moderate cost, probably below that of other methods of disposal in some areas. Detailed studies were made on 6 of the 114 artificial reefs on the U.S. East Coast but information was obtained on 20. Preliminary findings indicate improved fishing and usefulness where dredging has damaged the sea bottom. 16 references are given.

Tire Reefs Spawn New Fishing Grounds, Anon, Chemical Week, 1974 (March 20), 31-32. Success story of artificial reefs.

Scrap rubber diposal problems, Palmgren Hans,(Trelleboys Gummifab.AB) SGF (Sver. Gummitek Foeren) Publ. 1972 No. 39 III, 23pp. (Swedish) A review with 36 references.

Recycling scrap tires. Ganslandt, E, SGF Publ. 1972 No. 39, IV, 19 pp. (Swedish) Preprocessing of scrap rubber will grow in importance as the price of crude oil rises. The disadvantages of re-using rubber from tires (i.e. low strength, poor appearance, restricted choice of colours, will eventually be outweighed by the accumulation of used tires and related problems (no references).

Increase in the fertility of soils and their erosion resistance (resulting from polymeric conditioner use).Revut I.V., Romanov I.A. Maslenkovu G.L. Plast. Massy 1972 (10), 64-6. Rubber butadiene-styrene, SKS50 (0.2 - 0.3% solution, 75-300 kg polymer/ha) and SKS50 GP mixtures with vaseline oil emulsions formed around soil aggregates an elastic, stable and long lasting filmincreasingthe soil aggregates water stability, soil water permeability and resistance of soils to erosion at wind speeds 20 - 27 m/m. Other soil properties and soil fertility were also improved (In Russian)

Rubber recovery from scrap rubber, Kohler, R.H. (Union Carbide) Fr 2107597, 9 June 1972, U.S. Pat. Appl. 71,896, 14 September 1970. Rubber degradation, air pollution and recovered particle size were reduced by cooling the scrap rubber with liquid nitrogen at -197^{o} then pulverising the cooled material and mechanically separating rubber from fibres and metallic pastules. Thus rubber scrap ground at -196^{o} give particles 0.045 - 0.297 mm diam. compared with 0.149-0.297 mm if processed at room temperature.

OCCUPATIONAL HEALTH HAZARDS

Rubber Workers Study: Mortality and Morbidity Approaches (Pt. II), W.Burgess, Industry and Tropical Health:VIII, Industrial Council for Tropical Health, Boston, Mass. 1974.

This describes the initiation of health and environmental surveys at 13 plants belonging to 2 major U.S. rubber companies, which form part of the Joint Occupational Health Programme set up by industry managements and unions.

An Epidemiological Study of Mortality within a Cohort of Rubber Workers, 1964-72, A.J.Michael, R.Spirtas, L.L.Kupper, Paper for Amer. Indust. Hygiene Conf., Miami, 1974.

The introduction provides an excellent historical review of deaths and illness due to occupational exposures in the industry. The remainder covers the first phase of studies of about 6700 male rubber workers in a major tire plant. Overall death rates were slightly lower than for the corresponding age group of all U.S. males. However, for some specific causes of death the rates were significantly higher- these included cancer of the stomach, prostate and blood & lymph forming systems; for the 40-49 age group, ischemic heart disease and diabetes mellitus were also elevated. In 5 other plants, lung, bladder and central nervous system cancers were also raised. In the next phase individual groups of workers will be studied.

A Survey of Occupational Cancer in the Rubber and Cablemaking Industries, Results from a 5 Year Analysis, 1967-71, A.J.Fox, D.C.Lindars and R.Owen, Brit.J.Indust. Med. 1974, 31, 140-151

Records of about 41000 workers were studied. This shows no excess risk of bladder cancer among men entering the industry after β-naphthylamine was withdrawn. Bronchial cancer is excessive in tyre manufacture, belting hose rubber with asbestos, and flooring industry (which also uses asbestos). In the tyre industry (16000 men) the excess was in moulding, press, autoclave and pan cureman, and in packaging and despatch- the latter may be influenced by job selection.

Environmental Health Control for the Rubber Industry, W.E.McCormick, Rubb.Chem. Technol.Pt.I -1971,44,12-33 and Pt. II -1972,45,627-637.

This is a standard reference to chemical hazards in manufacture and processing of rubber which is impossible to summarise. More than 150 references are given.

Exposure to Chemical Agents in the Rubber Industry, N.H.Noweir, A.A. El-Dakhakhny and H.A. Osman, J.Egyptian Pub. Health, XLVII, 1972, 182-201.

After review of diseases in rubber workers and toxicity of chemicals used, this paper describes environmental measurements at a number of processes. Although increased incidence of respiratory, gastrintestinal, skin and eye-diseases are evident, these could not be related to the environmental measurements of dust and gases. The effects may be due to synergism, but detailed studies of envir0nmental factors are required.

Living with Carcinogens, H.G.Parkes, Rubber Industry, Feb.1974,21-23.

This presents a balance review of our carcinogenic environment, discussing in particular industrial use of β-naphthylamine, MOCA, and ethylene thiorurea. He stresses the need to maintain an effective systems to monitor the prevalence of diseases in the various occupational groups.

Rubber Allergies, W. Hofmann, Tech. Notes for the Rubber Industry, No 46 (Date unknown).

A very brief review of allergy producing chemicals used in rubber.

Note. A standard work on skin problems in industry (Occupational Diseases of the Skin, L. Schwartz, L.Tulipan,D.J. Birmingham, Lea & Febiger,Philadelphia, 1957) devotes one chapter of 20 pages to Dermatoses in the Manufacture of Rubber.

Two Views on Ways for Extrusion Plants to Implement their Health And Safety Programmes -1. A Consulting Engineer's Recommendations, J.P. Dyer, SPE Journal, 1973, 29, 27-31.

This includes cost estimates for providing ventilation and noise control.

Bladder Cancer and Carcinogenic Impurities in Rubber Additives, A.Munn, Rubber Industry, Feb.1974, 19-20.

This review of the largely fortuitious discovery of indutrial bladder cancer in the rubber industry, and subsequent events in the UK makes interesting reading. The question of "safe" products and exposure levels is fully discussed, and the effects of legislative decisions on compensatble disease are reviewed

What's New from OSHA ? Keep an Eye on NIOSH, R.R. Macbride, Modern Plastics International, June 1973, 55-57.

A short review of recent developments in safety and industrial toxicology which is relevant to the rubber industry. Includes a status report on the all-important OSHA (Occupational Safety and Health Act) standards for chemicals used in the rubber and plastics industry.

Bladder Tumours and Occupation: A Coroner's Notification Scheme, C.A.Veys, Brit.J. Indust. Med. 1974, 31, 65-71.

About 4000 deaths in England and Wales in 1971 were due to bladder cancer. This reports a local scheme for investigating all reported cases, which showed about 20% of cases had possible occupational exposure to a carcinogen, but in only 1/3rd of these could direct evidence be obtained. Of 105 male notifications, 11 were rubber workers, and 1 a cable worker. Two useful industrial checklists for occupational exposure to carcinogens are included and 37 references.

Epidemiological Considerations of Cancer of the Gallbladder, Bile Ducts, and Salivary Glands in the Rubber Industry, T.F. Mancuso and M.J.Brennan, J. Occup. Med., 1970, 12, 333.

From two independent prospective cohort studies and six retrospective studies it appears that specific chemicals cause these relatively rare cancers. Similar effects have been observed in animal experiments.

Toxicity in the Plastics and Rubber Industries and in their Products, J.M.J. Estevez, Plast. Polymers 37, 235-42, 1969

An Epidemiological Approach to the Rubber Industry. A Study Based on Departmental Experience, T.F.Mancuso, A.Ciocco, & A.A. El-Attar, J.Occup. Med., 10, 213-232, 1968.

The Toxicity of Rubber Additives. Findings from a Survey of 140 Plants in Ohio, H.C. Bourne, H.T. Yee, & S. Seferian, Arch. Environ.Health, 16, 700-5, 1968.

A description of the types of rubber additives, and the process involving their application in 140 Ohio fabricated rubber products plants, is given. The most frequently used additives found in the survey are listed. The toxicity and carcinogenic activity of these additives, mainly based upon a study of the literature, is reviewed.

Rubber Dermatitis -An Investigation of 106 Cases of Contact Dermatitis Caused by Rubber, H.T.H.Wilson, Brit. J. Dermatol., 81, 175-179, 1969.

Eczema Hazards in Working with Rubber and Plastics, (Eksemrisker vid arbeten med gummi och plast). S.Fregert, Säkerhetskonferensen i Malmö, Varen 1967. Skanska Cementaktiebolaget, Centrala Säkerhetstjänsten, Malmö, Sweden.

Paper presented to the occupational safety and health conference organised by Skånska Cement AB, Malmö. Following definitions of toxic and allergic eczema, the author discusses hazards which rubber and its constituents present to the skin, not only in the production of rubber, but also in the many workplaces (rubber gloves, cables, hoses, packing, etc). Additives, such as antimony oxide, which cause eczema, are present in plastics; thiuram sulphides (vulcanisation accelerators) are also used as pesticides and may be present in cutting oils. As semi-products, phenol formaldehyde resins may cause allergies, but eczema occurs most frequently in connection with epoxy resins; PVC, PVA and alkyd resins present further hazards (paint additives). Recommendation are made for avoiding contact allergies and eczema. A report of the subsequent discussion is included. (in Swedish ?)

Problems of Sanitation of the Working Conditions in the Production of Leather Substitutes (Rubber) for Shoe Soles. N.N.Krasnoshchokov, Sb Nauchn. Rabot Inst.Okhrany Truda, Vses.Tsentr.Sov.Profsoyuzov, 1962,4,68-74. Chem Abstr.61,3608a, 1964.

In the air of working areas in preparatory shops of black rubber production, 61-400 mg/m^3 carbon black is present during the weighing out, and 95-127 mg/m^3 during the charging of the rubber mixers. Large carbon black particles (6.6-19% > 50μ), containing a noticeable amount of carcinogenic 3,4-benzopyrene, can cause cancers. In the preparatory shops for coloured rubber production in dust tests, 45-51% SiO_2 was disclosed, which presents the danger of silicosis. In the rolling sections, the air environment was contaminated with hydrocarbons in concentrations of 0.6-2.3 mg/l in black rubber production, and 0.12-0.29 mg/l in coloured.

Problems of Industrial Hygiene in the Production of Synthetic Butadiene-Acrylonitrile Rubbers. G.P.Babanov, Gig. Truda i Prof. Zabol.1960,4,7. (in Russian, English Abstract)

Toxicology of Plastics and Rubber - Plastomers and Monomers, R.H.Wilson & W.E. McCormick, Indust. Med. 1954, 23, 479.

Medical Problems in Rubber Industries, S.V. Bhatt, Proc.Soc.for Study Indust. Med.2, 101, 1953. Bull.Hyg.1954, 29,37?.

Adjuvants in the Manufacture of Rubber as Producers of Eczema, W.P.Hermann, K.H.Schultz, Dermatologica 120, 127, 1960. J.Occup. Med. 2, 561, 1960

Allergy in the Rubber Industry, R.H.Wilson, E.H.Planck & W.E.McCormick, Indust. Med. & Surg. 28, 209, 1959.

Toxicological Characteristics of New Rubber Mixture Ingredients, R.S. Vorob'yeva, N.B.Mezentseva. Translation JPRS:30,850 from Gig.Truda Prof.Zabol. 8, 7, 39, 1964. Food & Cosmet. Toxicol 5, 269, 1967.

Comparative Toxicity of New Vulcanizing Agents. T.A.Kozlova et al, Gig.Sanit. 37, 106-7, 1972. (In Russian)

Hygienic Working Conditions in the Production of Polysiloxane Rubbers, G.Rozina, Yu Kremniorg. Mater. 1971, 273-6.

HCl and Si compounds are emitted during polysiloxane rubber manufacture from Me_2SiCl_2. Control methods are discussed. (in Russian)

Occupational Dermatoses of Workers Engaged in Butadiene-methylstyrene Rubber Production, I.M.Mirzoyan, Gig.Truda Prof. Zabol, 1972, 11,38-40.

The main factor is sensitisation by chemicals used such as α-methylstyrene, tert-dodecyl mercaptan, Neozone D, pyridine, hydrocarbon mixtures, aldehydic fraction, hydroxylamine, latex and oven finished rubber, by their fat-depriving or alkalising action. The prophylaxis of occupational skin diseases include sanitary-technical and sanitary-hygiene measures as well as individual protection. (in Russian)

Biopotentials of Skin of Persons working in an Atmosphere of Hydrocarbons, M.D.Glikshtein, V.G.Knabengof, Tr.Azerb.Nauch-Issled Inst.Gig.Truda Prof. Zabol., 1971, 7, 61-5.

The electrocutaneous biopotentials of workers producing butyl rubber was determined and related to the effect of MeCl, isoprene, and isobutylene. An asymmetry of cutaneous biopotentials appeared after several observations and had no determining role in evaluating the physiological reaction activity of the workers. The biopotential level of workers employed in chemically noxious atmospheres decreased gradually with increasing years of service. (in Russian).

Euphorbia Royleana Latex Keratitis, Sofat et al, Am. J. Opthalmol, 1972, 74, 634-70.

The Effect of Ethyl Benzene on the Upper Respiratory Tract and Protective Measures for Workers, L.V.Anokhin, et al, Zh.Ushn.Nos.Gorl.Bolezn, 1970, 30, 4-9. (in Russian).

Effects of Various Types of Rubber on Food Products and Extracts from these Rubbers on the Body, Kravchenko, Vrach Delo, 1972, 3, 130-3. (in Russian)

Characteristics of Work Conditions and Health Status of Automobile Tyre Vulcanisers, Shirokov, Gig.Truda.Prof.Zabol, 1972, 16, 16-19. (in Russian)

Toxicological Characteristics of Xanthanic Hydrogen - a New Rubber Release Agent, V.A. Volodchenko, Gig. Sanit. 36, 105-6, 1971 (in Russian)

Carcinogenic Properties of Certain Rubber Additives, E.Boyland et al, Euro. J. Cancer, 1968, 4,233-9

Bladder Carcinoma in Rubber Workers,A.C.Guira, J.Urol, 1971, 106, 548-52.

Incidence of Chronic Bronchitis in the Rubber Industry, W.Schunk, Z.Gesamte Hyg.,1971, 17, 853-6. (in German)

Hygienic Evaluation of Various Samples of Relime, A.N.Bokov, Gig. Sanit. 1971, 36, 21-5 (in Russian)

Allergy to Rubber Accelerators, E.Rudzki et al, Pol.Tyg. Lek.,1973, 28, 1546-8. (in Polish)

Hygiene Characteristics of Urethane Rubber Manufacture and Health Status of Workers, V.S. Filatova et al, Gig. Truda Prof.Zabol.,1973, 17,41-43. (in Russian)

Technical Progress and Means of Improvement of Labour Conditions in the Production of Rubber Articles, Bagdinov, Gig. Sanit., 1973, 38,25-29. (in Russian)

Damages for Rubber Workers, Editorial, Brit. Med.J.,1971,2, 412-3.

Aromatic Amine NA4010 (IPPD) (N-phenyl-N isopropyl-paraphenylene diamine) Its importance in allergy to tyre rubber, P.Bubor, Arch.Mal.Prof.,1971,32, 308-312. (in French)

Experience in the Study of Working Conditions and Health of Adolescents Working at the Occupational Technical Schools of the Rubber Shoe Industry, Petrunicheva, Gig. Sanit.,1970, 35, 95-6. (in Russian)

Physiological Changes in Machine Operators in the Isoprene Rubber Industry, S.A.Pigolev, Gig. Truda Prof. Zabol., 1971,15, 49-50. (in Russian)

Hygienic Significance of Some Measures Aimed for the Improvement of Technology of the SKMS Rubber Production, N.K. Dvorianinova et al, Gig. Truda Prof. Zabol.,1972, 16, 33-5. (in Russian)

Occupational Dermatoses in Workers Engaged in the Production of Divvinylmethyl styrene Rubber, I.M.Mirzoian, Gig.Truda Prof. Zabol., 1972, 16, 38-40. (in Russian)

The State of the Genitals of Workers in Tyre and Asbestos Factories, E.A. Lebedeva, Akush Ginekol (Mosk.), 1971, 47, 74-5 (in Russian)

Effect of Chemical Substances Isolated from Isoprene Rubber SKI-3, Pestova et al, Vrach Delo.,1973, 4, 135-7. (in Russian)

Experimental Study of the Allergenic Properties of bisfuralidene hexamethylenediamine Administered via Various Routes, A.D. Chernousov, Gig Sanit.1972, 37, 34-7. (in Russian, English abstract)

Functional State of the Kidneys in Workers Engaged in the Production of Divinylalphamethylstyrene Rubber, Konstantinovskaia, Gig. Truda.Prof. Zabol., 1970, 14, 10-12. (in Russian)

The Effect of Sulphuric Acid and Ethyl Alcohol on the Eye in Butyl Rubber Production and Methods of Prevention, Sh.Kh.Ismail Zade, et al, Oftalmol.Zh., 1970, 25, 584-6. (in Russian)

Occupational Diseases of the Skin in Workers Engaged in the Production of Isoprene Rubber, S.A. Pigolev, Vestn. Dermatol.Venerol., 1971, 45,64-5 (in Russian)

Contact Eczema Caused by Fluid Polysulphide Rubber Latox, V.Ziegler et al, Dtsch.Gesundheitsw., 1970, 25, 2006-7. (in German)

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