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27 July 1990

Dear Sir,

In the June 1990 newsletter of the ACOM Report, there is reference to NIOSH investigating hazards of occupational exposure to cutting fluids. I enclose a copy of the proceedings of a conference which was held at the Institute of Occupational Health, University of Birmingham, on 'The Health Hazards of Cutting Oils and their Controls' (1989) which you may find of interest.

Yours sincerely,

T C Aw
University of Birmingham

THE UNIVERSITY
OF BIRMINGHAM

PROCEEDINGS OF A CONFERENCE ON THE HEALTH HAZARDS OF CUTTING OILS AND THEIR CONTROLS

Editor: D C Glass

Institute of Occupational Health
Proceedings 1989 No 1

CONFERENCE ON THE HEALTH HAZARDS OF CUTTING OILS AND THEIR CONTROL

PROCEEDINGS
OF A CONFERENCE ON HEALTH HAZARDS
OF CUTTING OILS AND THEIR CONTROLS

HELD on 28th and 29th APRIL 1988
THE UNIVERSITY OF BIRMINGHAM
Faculty of Medicine and Dentistry

A SYMPOSIUM ORGANISED
BY THE INSTITUTE OF OCCUPATIONAL HEALTH
THE UNIVERSITY OF BIRMINGHAM

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Ms D C Glass

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FOREWORD

A very successful conference entitled "The Health Hazards of Cutting Oils and their Control" was held at Birmingham University Institute of Occupational Health in April 1988. This book contains the papers presented and edited transcripts of the question and answer sessions. Three additional papers were solicited after the conference, one on the safe use of biocides and two on the design of machine tools. Both of these areas were identified by the conference participants as ones that should be addressed but were not dealt with as specific topics by the conference speakers. The views expressed in the papers are those of the individual author's and should not be taken to be those of the Institute of Occupational Health.

The conference was attended by over 72 people from the UK and other European countries, and as can be seen by the length of the question sessions a lively debate was generated.

The success of the conference was largely due to the efforts of Mark Piney who planned and organised the conference and the exhibition.and Joyce Blake who administered them so efficiently.

My thanks are due to Mark Piney and the authors for their written contributions and to Caroline Baxter, Jane Hill, Samantha Roberts and Joyce Blake for help with the transcript and to Sue Shackleton for the bibliography.

Ms. Deborah C. Glass

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INSTITUTE OF OCCUPATIONAL HEALTH.

BIRMINGHAM UNIVERSITY.

THE HEALTH HAZARDS OF CUTTING OILS AND THEIR CONTROL

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A TWO DAY CONFERENCE

TO BE HELD BY THE INSTITUTE OF OCCUPATIONAL HEALTH
AT
THE UNIVERSITY OF BIRMINGHAM

ON 28TH AND 29TH APRIL 1988

***

Day 1: Thursday 28th April

08.30 - 09.30
Registration and coffee

09.30 - 09.40
Welcome and introduction to the conference
Mr. M. Piney - Honorary Lecturer in Occupational Hygiene, Institute of Occupational Health

09.40 - 10.10
Composition of metal working fluids:
Mr. P.J. Ruane - Senior Development Chemist, Castrol Ltd.

10.10 - 10.55
The health effects of cutting fluids on the lung:
Dr. P.S. Burge, Consultant Chest Physician, East Birmingham Hospital.

10.55 - 11.05
Questions

11.05-11.35
Coffee

11.35 - 12.10
Microbial contamination of metal working fluids:
Mr. E.C. Hill, Lecturer, Microbiology Department, University College, Cardiff

12.10 - 12.55
Dermatitis and cutting fluids:
Dr. R.J.G. Rycroft - Consultant Dermatologist, St. John's Hospital for Diseases of the Skin; and Employment Medical Advisory Service, London.

12.55 - 13.10
Questions

13.15 - 14.15
Lunch and Exhibition - (Exhibition in Chamberlain Museum, Medical School, 1st floor)

14.15-14.45	**Cancer and cutting oils - the past and present:** Dr. J. Waterhouse - Birmingham Cancer Registry and Honorary Lecturer, Institute of Occupational Health
14.45-15.15	**Cancer and cutting oils - treatment and prognosis:** Prof. M. Cooke - Honorary Senior Clinical Lecturer, Institute of Occupational Health
15.15-15.30	**Questions**
15.30-16.00	Tea
16.00-16.30	**Inhalation hazards from microbially infected cutting oils - the current position:** Mr. E.C. Hill, Lecturer, Microbiology Department, University College Cardiff
16.30-17.00	**Panel discussion all speakers**
17.00	**Close of first day** (Exhibition open until 18.00)

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Dav 2: Friday 29th April

09.30-10.15	**The assessment of oil and coolant mists and their control:** Mr. G. Lee - Group Occupational Hygienist, Austin Rover Group Ltd.
10.15-10.45	**Control of potential health hazards by formulation practice:** Mr. P.J. Ruane, Senior Development Chemist, Castrol Ltd.
10.45-11.00	**Questions**
11.00-11.30	Coffee
11.30-12.00	**Controlling microbiological contamination of cutting fluids:** Mr. R.B. Weaver, Marketing Manager, Paul de la Pena Oils Ltd.
12.00-12.10	**Questions**
12.10-13.15	**Lunch and exhibition**
13.15-13.45	**The industry's view of the health hazards of cutting fluids:** Mr. P. Oates, Manager Industrial Technology, Castrol Research Laboratories
13.45-14.15	**The Health and Safety Executive's view of the health hazards of cutting fluid** Dr. N.J.T. Long, HM Inspector of Factories, Engineering National Industry Group, Health and Safety Executive
14.15-14.45	**Panel and discussion with all speakers**
14.45-15.15	Tea
15.45	**Close of Conference**

INTRODUCTION TO THE CONFERENCE

Mr M Piney - Honorary Lecturer in Occupational Hygiene
Institute of Occupational Health

Metalworking fluids are used in small or large amounts in most, if not all, manufacturing industries. They can be a significant running cost and their stability and quality have a vital impact on the quality and rate of production. Metalworking fluids can also adversely affect the health of those people that work with them.

Health Effects

Neat mineral oils can cause skin and scrotal cancer. The risk is much reduced in the UK due to the use of solvent refined oils but the risk may still exist for some groups workers.
Certain constituents and contaminants of oil can lead to occupational asthma. Dr S Burge, who will be addressing this Conference, summarised his view of the problem as follows:
"Over the last 5 years in Birmingham it has become clear that occupational asthma occurs in workers exposed to cutting oil mists. In fact, in my clinic oil mists are the most commonly recognised cause of occupational asthma."

Of the prescribed diseases, dermatitis is the biggest cause of lost time of work in the UK. It accounts for around 65% of the prescribed disease total every year and represents approximately 10,000 people who have to be take time of work, sometimes for weeks. Approximately 2,500 or 25%, come from the metal manufacturing and engineering industries. Most of this dermatitis is caused by soluble oils and it often represents the tip of the iceberg. One study of 100 machine operators found that about one third had some degree of dermatitis which was uncomfortable and unpleasant but it was not bad enough to cause people to take time of work. The problem is often endemic and goes unrecognised.

Soluble oils can become highly infected with bacteria and sometimes fungi. Such contamination not only causes objectionable smells and slime but also blocks filters, leads to acidity and corrosion, blinds grinding wheels, causes poor surface finishes and shortens service life. It may, in some cases, help lead to outbreaks of dermatitis and could pose an inhalation health hazard.

The Conference

The Conference examines the health and production problems that can occur when using metalworking fluids and then goes on to consider practical methods of controlling both. It is my perception that the subject that we are dealing with today and tomorrow does not often get a public airing. Various parts of it do but the subject as a whole does not. As we shall see the cutting fluid industry is rapidly changing and innovative and the potential health hazards have changed over the years. Some have waned while others have appeared. The Institute is concerned to run a Conference which is not just a list of problems but also explores solutions. This the particular focus of day 2. We feel that the Conference is timely given relevantly imminent arrival of the Control of Substances Hazardous to Health Regulations and the fact that the HSE is preparing a guidance note on the health hazards of cutting fluids. From the delegate list it would appear that about 50% of the audience are from the engineering industries, about 25% are from the oil supplies industries and the rest fit into various categories. Such an interesting mix of people should stimulate a healthy and broad ranging debate. There is one change to the programme, regrettably the Trade Union speaker has had to withdraw at the last minute due to unavoidable work commitments. (We had hoped to include a paper from Mr S Schmoller but unfortunately he was not able to meet the publication deadline.)

The speakers that we have assembled are experts in their field and have years of experience in dealing with the health hazards of cutting oils and their control. I hope you enjoy the conference.

THE COMPOSITION OF METALWORKING FLUIDS

P J Ruane - Technology Division, Castrol Limited

1. Introduction

The purpose of a metalworking fluid is to aid the process of changing the shape or composition of metal, which normally involves plastic deformation (metal forming) or the removal of excess material in a controlled manner (metal cutting). Metalworking fluids play a major role in many manufacturing processes, and can have a significant bearing on process efficiency, productivity levels, operator acceptability, energy levels and safety. Choice of the correct fluid is vital if all process requirements and any additional parameters are to be fully achieved, and the suitability of the chosen fluid will depend for the most part on its general type and chemical composition.

The main emphasis of this conference is on cutting oils and therefore this paper will in the main be devoted to describing the composition of metal cutting fluids, although virtually all the additives discussed are common to the many types of metal forming products currently available. However, there are a small number of additives which are only seldom incorporated into cutting fluids, such as solid lubricants, and these are briefly discussed later.

This paper does not seek to condone or justify the use of any of the additives or chemicals mentioned, its purpose is purely to identify the types and classes of additives which have been or are currently in use in particular metal cutting fluids. Only where use in such fluid requires distinct characteristics of the additive will any reasons for its incorporation be addressed. In addition it is not the author's aim to favour one type of fluid over another any advantages or criticisms implied in the text are entirely unintentional.

2. Types of Metal Cutting Fluid

There are three major types of metal cutting fluids; neat oils, emulsifiable oils and water soluble synthetic fluids (1). Neat oils are essentially ready to use and are normally designed to be non-miscible with water. Emulsifiable oils are normally based on a mineral oil or other water insoluble hydrocarbon fluid and contain specific chemicals called emulsifiers which promote dispersion of the concentrate when mixed with water, and which produce oil in water emulsions, although there are a number of water in oil emulsions which are used for special purposes. Oil in water emulsions may be milky, translucent or clear depending on the balance of emulsifiers to base fluid. Water soluble synthetic fluids, also known as synthetics or chemical fluids, contain no mineral oil and are usually based entirely on water soluble chemicals.

In addition to the above there is a further type of fluid often called a semi-synthetic fluid, which can be considered a cross between an emulsifiable oil and a water soluble synthetic fluid. It normally refers to products which have a low emulsified oil content and which upon dilution with water, produce clear emulsions. As yet no authoritative body within Western Europe has specified the maximum level of oil in a semi-synthetic fluid. Opinions vary between limits of 10 and 50 percent, but it is not the intention of this paper to propose such a specification.

3. Neat Oils

The simplest examples of neat oils are straight uncompounded mineral oils which essentially fall into 3 types, although a more detailed classification is available (2).

3.1 Paraffinic Oils

These are oils that have been produced from paraffinic crudes by severe solvent refining or deep hydrotreatment processes followed by dewaxing. They are characterised by good oxidation stability, high viscosity index and high pour points.

3.2 Napthenic Oils

Again these oils are produced by severe solvent refining or deep hydrotreatment, but as naphthenic crudes have a low wax content they normally do not require further dewaxing. The oxidation stability and viscosity index are not as good as those of paraffinic oils, but due to their low wax content the pour points are usually lower.

3.3 Aromatic Oils

These essentially consist of vacuum distillates of either paraffinic or naphthenic crudes which may or may not undergo further treatment. Aromatic oils are characterised by poor oxidation stability, low viscosity index and low pour points.

In 1968 a study (3) suggested that certain types of polycyclic aromatic hydrocarbons (PCAH) existed in unrefined fractions of crude oils. On the basis of this study the Institute of Petroleum advised member companies (4) to base neat metalworking oils on oils which had been solvent refined or treated in other ways so as to give an appreciable reduction in the content of PCAHs. This recommendation, followed by the judgement in the Stokes - v - GKN case, later the same year, ensured that during the early 1970s those manufacturers of neat cutting oils who had not already done so, reformulated their products onto oils other than the aromatic type with their inherently high PCAH contents (5).

In addition to mineral oils, neat oils can also be based wholly or in part on synthetically derived hydrocarbons, such as poly alpha olefins (PAOLs), heavy alkylates or polyisobutenes, which can often impart additional desirable properties to the finished fluid.

Whilst simple uncompounded oils are suitable for the less severe operations where hydrodynamic lubrication predominates, for more severe operations where the boundary lubrication condition occurs, the presence of load carrying additives is necessary. These may be conveniently subdivided into two types namely lubricity additives and extreme pressure (EP) additives.

3.4 Lubricity Additives

Lubricity additives are usually polar molecules which have a reactive group at one end which has an affinity for metals. The molecules of the additive form a tenacious film on the metal surface which is retained at pressures at which mineral oil alone is displaced.. Examples of these polar lubricity additives are natural fats, fatty acids, synthetic esters, certain waxes, and metal soaps.

As the pressure between the cutting tool and the metal surface increases further, the film of lubricity additive is ruptured and friction can only be overcome by the use of extreme pressure additives.

3.5 Extreme Pressure (EP) Additives

Extreme pressure additives contain elements, particularly sulphur, chlorine and phosphorus, which at the high localised temperatures caused in the cutting zone are able to combine with the metal. The resulting compounds act as solid lubricants and prevent intimate contact between the tool and workpiece reducing the possibility of welding of the two surfaces. The choice of additive is generally governed by the material being machined, for example sulphur containing EP additives are normally avoided when machining yellow metals due to the formation of dark sulphide stains. However, the effectiveness of sulphur, chlorine and phosphorus based additives varies considerably and for particular operations synergistic mixtures of EP additives may be required where a single additive is incapable of providing the necessary level of performance.

3.5.1 Sulphur based EP Additives

The simplest form of this type of additive is flowers of sulphur, which when dissolved in a hydrocarbon base fluid is a very effective agent for metal cutting. In this form the sulphur is very reactive and will stain copper readily, and additives containing sulphur which react in this way are said to be "active". Examples of this type of additive are certain sulphurised fats, esters, fatty acids and hydrocarbons. It is possible to combine sulphur in such a way as to render it "inactive" to copper, and inactive sulphurised additives, which are usually sulphurised fats and certain polysulphides can be utilised more widely as a result. However, it has been found, both experimentally and in practice, that particularly in ferrous machining active sulphurised additives confer better extreme pressure properties than their inactive counterparts.

3.5.2. Chlorine based EP Additives

Although chlorine itself is a green, poisonous gas, when combined in certain molecules, typically chlorinated paraffins, chlorinated paraffin waxes, chlorinated fats/fatty esters/fatty acids, it is an extremely effective extreme pressure additive. Chlorine reacts and functions at the cutting zone in much the same manner as sulphur, but since it is more reactive it combines with the workpiece metal at significantly lower temperatures. Unlike their sulphur containing counterparts, chlorine-bearing extreme pressure additives do not stain most non-ferrous metals. However, because of their high chemical reactivity, chlorine-bearing additives are almost always compounded with inhibiting or neutralising ingredients to prevent corrosion of ferrous metals due to the release of excessive hydrogen chloride, usually caused by heat or contamination with water. Examples of inhibitors commonly used are organic epoxides, phosphites, overbased petroleum sulphonates, and certain fatty amines.

3.5.3 Sulpho-chlorinated EP Additives

It has long been known that mixtures of chlorine and sulphur based additives can act synergistically in terms of machining performance. It is possible to introduce chlorine and sulphur onto the same molecule, for instance by reacting an unsaturated substrate such as natural fat with Sulphur Monochloride. Under the correct conditions a sulpho-chlorinated fat is produced normally containing nearly identical percentages of both sulphur and chlorine. These sulpho-chlorinated additives, commonly sulpho-chlorinated mineral oils, fats, esters and fatty acids are probably the most active EP agents currently used in metalworking, and find use in neat oils designed for use in the most severe applications such as broaching. However, as with the chlorinated additives, their reactivity can lead to severe staining problems on a number of metals and high levels of corrosion inhibitors are often necessary, which in practice has meant that their use has been somewhat restricted.

3.5.4 Phosphorus based EP Additives

Phosphorus, usually in the form of an organic or organo-metallic phosphate functions as a relatively mild extreme pressure lubricant. It has lower anti-weld properties than chlorine or sulphur and is more suited to reducing friction and wear. The most common types of phosphorus based EP additives normally used are phosphate esters such as Tri-Tolyl Phosphate, and organometallic phosphate such as Zinc Dialkyl Dithiophosphates (ZDDPs). Most phosphorous EP additives are non-staining to both ferrous and non-ferrous metals.

3.5.5 Other EP Additives

In recent years a "new" series of extreme pressure additives has been developed. These have been referred to as passive extreme pressure additives (6), and are based on the technology of overbased sodium and calcium petroleum sulphonates. Although not as yet widely accepted they have proved highly effective both alone, or more usually combined with other EP additives such as polysulphides, in several of the more difficult metalworking operations. They have a number of inherent advantages over conventional EP additives, particularly as regards corrosion, but due to the level of overbasing some compatibility problems can occur with other additives such as natural fats and fatty acids.

3.6 Other Additives used in Neat Oils

In order to meet specific process or operational requirements, a vast array of other additives may be used in neat oil formulations. Among those commonly incorporated are: antioxidants, viscosity index improvers, pour point depressants, anti-mist additives, tackiness additives, corrosion inhibitors, metal passivators, scourability additives, dyes, scents and reodorants and finally antifoams.

The reason for the use of most of these additives are self evident, but in certain instances a slightly more detailed explanation for their use is warranted.

Tackiness additives improve the adhesive properties of the lubricant film to the metal surface. They induce "stringiness" or structure in the finished product which allows it to maintain its integrity under load. The most commonly used additives of this type are high molecular weight polymers and certain metal soaps.

Although neat oils are generally formulated so as not to be miscible in water, in certain operations it is advantageous that the cutting oil can be removed from component by water washing. A wide range of emulsifiers can be used to render neat oils removeable or "scourable" in this manner, although perhaps the most common are alkyl phenol ethoxylates and polyglycol esters.

Foaming problems are usually associated with water miscible fluids, particularly emulsifiable oils, but in certain operations such as flute grinding of twist drills severe air entrainment into the grinding oil can occur. Although many of the inherent problems in this context can prevented by correct base oil and additive selection, in some circumstances an additional foam control agent is necessary. Typical foam control agents used for this purpose are silicone fluids and high molecular weight propoxylates.

4. Emulsifiable Oils

In general terms emulsifiable oils can be considered to be neat oils which by the addition of emulsifiers and other additives can be dispersed as discreet oil droplets in water. Most emulsifiable oils are based on a paraffinic or naphthenic mineral oil, although as with neat oils other synthetic hydrocarbons can be used. Aromatic mineral oils (ie, those derived from vacuum distillates) may still be used and certainly the study previously referred to (3) indicated that there was evidence that emulsions of these oils were less hazardous than their neat oil counterparts. However, in practice their use is normally restricted to a very small number of emulsifiable oils, where they are incorporated purely for technical reasons. Emulsifiable oils containing load bearing additives of the types used in neat oils are often termed highly fatted, (lubricity additives) or EP (extreme pressure additives) soluble oils. Although the load bearing additives used are usually water insoluble, a number of water soluble or water dispersible lubricity and EP additives are utilised.

The dispersion of oil into water is effected by emulsifiers which stabilise the dispersion by reducing the interfacial energy such that the charges on the oil droplet repel all other droplets. Emulsifiers are classed by the charge they impart to the emulsified droplet, and in the vast majority of cases these will be anionic or non-ionic, cationic being relatively rare, particularly in metalworking oils.

4.1 Emulsifiers

For many years the most commonly used primary emulsifiers were petroleum sulphonates, either natural or synthetic, or fatty acid soaps. Petroleum sulphonates were generally not used alone since, although they were able to form stable emulsions, the pH of those emulsions was normally too low to ensure long term emulsion stability since it normally lay in the range 7-8 where bacterial activity is at a peak. For this reason fatty acid soaps were used, which together with petroleum sulphonates, produced emulsions with the preferred initial pH range of 9-10.

In recent years, particularly with the development of biostable emulsifiable oils, many other emulsifiers have been utilised such as fatty amines, sulphonamidocarboxylic acids and sarcosines. These have often been aided by secondary emulsifiers such as succinamides, non-ionic surfactants and alkoxylated fatty acids in order to produce emulsions with additional desirable characteristics such as enhanced detergency and dispersancy.

The type of emulsion produced by an emulsifiable oil is generally related to the ratio of emulsifier to insoluble oil phase. The higher the emulsifier ratio the greater the tendency to produce clear emulsions (droplet size 0.1 micron). Reducing the emulsifier ratio will gradually coarsen the emulsion, eventually resulting in milky emulsions (droplet size 1.5 - 5 microns). In addition to emulsifiers a number of other additives are used in emulsifiable oils, most notably corrosion inhibitors, biocides, coupling agents, scents, dyes and antifoams.

4.2 Corrosion Inhibitors

Many of the emulsifiers used in emulsifiable oils as outlined above also confer corrosion inhibition properties on the finished product. Where enhanced corrosion inhibition, particularly on ferrous metals is required the most commonly used additions are alkanolamines such as triethanolamine. Until recently sodium nitrite was used extensively as a low cost corrosion inhibitor, but during the 1970s it was shown that nitrites could react with alkanolamines and other amines to produce nitrosamines (7). Certain nitrosamines such as nitrosodiethanolamine (NDELA) have been shown to be carcinogenic when tested on laboratory animals, and as a result marketing pressure rather than legislation directed the formulation of products which neither produced nor contained nitrosamines. However, in practice this has generally resulted in the formulation of products free from sodium nitrite. Further information on nitrosamines continues to be published (8).

The move away from sodium nitrite led to the development of a wide range of other water soluble corrosion inhibitors, which are covered more fully later in the section on water soluble synthetic fluids.

4.3 Biocides

Biodeterioration of emulsions was first described over 40 years ago (9). A wide range or biocides has been and continues to be incorporated into emulsifiable oil formulations, but for convenience they may be divided into three types:

i) Phenolic types eg., Ortho-Phenyl Phenol (OPP)
ii) Formaldehyde release types, eg., Hexahydro -1,3,5, tris (2-hydroxy-ethyl)-s-triazine
iii) Others, eg., Pyridinethiones

A number of reviews on biocides for aqueous metalworking fluids are available (10, 11) covering a very large number of individual chemicals, too numerous to satisfactorily cover here. However, several further points are worthy of mention: many biocides are only suitable for addition to the dilute emulsion due to problems of compatibility with many of the components utilised in emulsifiable oil concentrates. Often mixtures of biocides are utilised in a fluid formulation to take advantage of synergistic effects (12). Also it is known that certain sequestering agents such as EDTA can greatly increase the activity of biocides incorporated into cutting fluid concentrates (13). The development of 'biostable' coolants, usually based on boramides or boron amine esters (14) has led to the marketing of biocide-free emulsifiable oils, which produce emulsions that allow a controlled degree of bacterial contamination which does not seriously influence emulsion longevity. In the UK products of this type are establishing an increasing market share.

In addition to boron containing 'biostable' emulsifiable oils, other biocide-free systems which control bacterial contamination have been proposed, of which perhaps the best known involves use of copper complexes (15).

4.4 Coupling Agents

Coupling agents act as mutual solvents between the oil phase and aqueous phase and are added to produce a stable single phase mixture of all the additives present over the normal range of storage temperatures ie., 0 to 40^{o}C. Their performance is dependent on chemical type and structure, and the most common types are alcohols, glycols and glycol ethers. Certain coupling agents, such as xylenols, which are the basis of phenolic coupled emulsifiable oils, have other advantageous properties, such as anti-microbial activity.

4.5 Other Additives

Dyes and scents are added to emulsifiable oils, as they are to neat oils and water soluble synthetics to enhance operator acceptability. Since emulsifiable oils contain surface active agents such as soaps or non-ionic surfactants, there may be a tendency, particularly in soft waters for the freshly prepared emulsion to produce foam during use. Foam control agents such as silicones, water-insoluble waxes and polyglycols are often incorporated to control this foam generation until contamination of the emulsion by tramp oil, or machining debris on the emulsion surface helps to suppress the foam.

5. **Water Soluble Synthetic Fluids**

Water soluble synthetic fluids, often referred to as synthetics or chemical fluids, contain no mineral oil and are usually either true solutions or extremely fine colloidal solutions. In their simplest form the diluted versions of these fluids can be considered to be essentially non-corrosive water, since this was sufficient to satisfy the initial requirements for which they were designed, namely rapid heat removal whilst preventing rust. The earliest types of water soluble synthetic fluids were mixtures of alkanolamines and sodium nitrite which were used at low concentrations usually in grinding operations. With the trend away from the use of sodium nitrite, nitrite-free versions were produced based on a vast array of other water soluble ferrous metal corrosion inhibitors such as amine neutralised carboxylic acids, inorganic salts and boron compounds. In recent years there has been a trend to increase the scope of use of synthetic fluids by introducing additional additives such as dispersants, wetting agents, water soluble lubricity and EP additives so that quite arduous machining operations can be effected. Unfortunately in water soluble synthetic fluids the absolute level of performance available is often limited by the necessity to ensure that the resulting fluid has a low foam propensity when diluted with water. Wetting agents for instance improved the capacity of the fluid to wet out metal surfaces, often by reducing the surface tension. Choice of the wrong chemical type or use of an excessive concentration however, often leads to foaming problems in practice. For this reason particular low foam wetting agents such as acetylenic surfactants and block copolymers are normally used.

Dispersants are important additives in water soluble synthetic fluids in that they can control the suspension and deposition of metalworking debris, and in some cases prevent the build up of deposits on machine tools. Polymeric materials are widely used in this context with polyacrylates, maleic acid/olefin copolymers and substituted polyamines being perhaps the most popular types. As with emulsifiable oils, water soluble synthetics may also contain biocides, scents, dyes and antifoams where these are considered necessary.

6. **Solid Lubricants**

Solid lubricants such as molybdenum disulphide and graphite are used in certain specific metal cutting operations, such as tapping and thread cutting where they can be smeared onto the work zone, usually in the form of specifically formulated pastes or greases. However, the difficulties involved in maintaining a stable suspension of these solid lubricants in a base fluid, and separating debris from the resulting cutting operations from this suspension, have prevented their use in circulated fluid systems. Considerably greater use of solid lubricants is made in metal forming operations, particularly where deformation processes operate at speeds too low to activate EP additives, or generate temperatures too high to prevent complete additive breakdown. Here solid lubricants function effectively by presenting a physical barrier between the workpiece and tool. Additives used in this context, other than those above, are calcium hydroxide, calcium carbonate, talc, certain clays, sodium bicarbonate, powdered metals, ie., lead, and powdered inert organic solids such as PTFE.

7. **Concluding Remarks**

This present paper gives only a brief insight into some of the additives used in the composition of metal working fluids. A number of more extensive reviews are available in this context (16, 17) for those seeking further information on this subject.

The range and number of additives used in metalworking fluids is already vast and is growing continuously as a result of continuous research to produce products which perform better and are more acceptable to the end user and his environment.

The impact of actual or proposed legislation preventing or restricting the use of certain additives has often led to the rapid development of a wide range of alternatives from an alert and responsive cutting fluids supply industry. Where formulators may previously have had only a handful of additives, suitable for effecting a particular operation, there may now be several hundred. Additives which were considered irreplaceable in their day have now been replaced as a matter of course, and attention has moved on to the next challenge.

Whilst it is certain that in the future metalworking fluids will be more effective, safer to use and more environmentally acceptable, it is also highly likely that the composition of these fluids will be even more complex and varied than they are at present.

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THE HEALTH EFFECTS OF CUTTING FLUIDS ON THE LUNGS

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This paper describes some of the perceived respiratory hazards for people exposed to oil mists, most of which can be dismissed, the exception is asthma. The paper goes on to discuss occupational asthma in general and problems with oil mists in particular.

In many engineering shops there is a haze of oil mist in the air which is inhaled. Exposure can be in the order of 1-2 mg/m^3, well within the occupational exposure limit, despite this, individual workers may develop occupational asthma.

Lunq Cancer

Cancer of the skin has been a problem with mineral oil exposure, due to the contamination of oils with polyaromatic hydrocarbons. This has lead to the suggestion that the higher incidence of lung cancer seen in urban industrial communities might be due to the inhalation of oil mists. There is now good evidence that this is not true, (Hendricks, N.V. et al 1962, Ely T.S. et al (1970), Goldstein D.H. et al 1970); and that there is no increased risk of lung cancer from current inhalation of oil mists in engineering shops.

Lipoid Pneumonia

This used to occur after exposure to large amounts of medicinal paraffin taken by mouth and is now extremely rare. Cases due to oil mist exposure at work have been described, (Proudfit et al 1950, Foe et al 1954, Cullen et al 1981). It almost certainly does not occur as a result of current levels of exposure to oil mists at work.

Bronchitis

There are two diseases which are often confused with the same general title of bronchitis. Bronchitis strictly implies a productive of cough and phlegm which is common in many industrial situations, and is a protective mechanism of the lung clearing the inhaled material. Chronic Obstructive Bronchitis implies the addition of airways obstruction which is the main cause of respiratory disability. The prevalence of cough and sputum production (chronic simple bronchitis) among turners, hardeners, and grinders was studied by Jarvholm (1982). He looked at a population exposed to oil mists at concentrations at about half the exposure limit, for at least 3 years, and obtained an 89% response rate. He concluded that exposed non-smokers had more cough and phlegm than the control group and that this was related to oil mist exposure. Those people with respiratory symptoms had poorer lung function and poorer gas transfer than those who were asymptomatic but both populations were above average. This is almost certainly because of the healthy worker effect in the asymptomatic group.

Immunoglobulin (IgM) levels were compared with those of office workers and IgM levels were raised in the oil mist exposed workers. This is an unusual situation which has rarely been described in occupational groups; however electronics workers exposed to soldering fluxes containing colophony (a pine resin extract) have also shown raised total levels of IgM. Pine oil is widely used in oil-based products as a deodorant and colophony adducts are used as emulsifiers. It may be that the IgM levels in the oil mist exposed workers are related to colophony exposure. In the electronics workers, the IgM levels appear to be a marker of exposure rather than disease, (Burge et al 1981).

Morgan et al (1988), studied an engineering works with workers exposed to both mineral and soluble oil aerosols, 96% of the exposed population were examined. These were divided into workers exposed to mineral oil, those exposed to high and low levels of soluble oil, and an incidentally exposed group working in the stores and on an assembly line under the same general factory roof. Peak oil mist exposures were approx. 2 mg/m^3.

Work-related cough, wheeze and breathlessness, (that is symptoms that were better on days away from work), were highest among the mineral oil exposed group. Work-related sore and dry throats appeared to be dose related symptoms among the soluble oil exposed workers. Smoking rates were high, approx. 65% overall. The results are shown in figures 1 and 2.

Because the control group were incidentally exposed to oil mist, another control group was found. Comparison with workers from the galvanising industry, who were exposed to substantial amounts of fume but not to oil mist, showed a lower level of eye, nose and throat complaints. It may be therefore, that low levels of exposure to oil mist may cause these effects.

Occupational Asthma

Occupational asthma is asthma due in whole or in part to agents met with at work. Once a normal person has developed occupational asthma, he nearly always also has asthma related to non-specific stimuli such as cold air, fog, exercise and respiratory infection, which affect other asthmatics. It is therefore rare for asthma even wholly caused by work to be related only to work exposure. Nevertheless, it is possible to differentiate between occupational asthma and other environmental asthmas by finding deterioration in the asthma related to periods at work and improvement away from work. Once occupational asthma has developed, continuing exposure is likely to lead to worsening asthma and a smaller chance of complete recovery once exposure ceases.

Occupational asthma accounts for about 5% of all adult onset asthma, and at least in Birmingham, oil mist exposure is the commonest recognised cause of occupational asthma. However, occupational asthma due to oil mists has not been widely described elsewhere. The methods of diagnosing occupational asthma are well established and involve history taking, measurement of lung functioning in relationship to work, immunology (where appropriate), and bronchial provocation testing.

The most important way of making a diagnosis of occupational asthma is from the history. The two best screening tests are to ask a worker whether their symptoms of airways obstruction improve on days away from work or on holiday. Those with occupational asthma will be found amongst these two groups. Workers who improve on holiday may also avoid domestic allergens, so holidays at home need to be differentiated from holidays away from home. Some workers with occupational asthma do not improve on weekends away from work as longer periods are required for recovery to start. There are different patterns of deterioration in relationship to exposure which are seen in general, and in oil mist exposed workers in particular, and it may be that there are different mechanisms involved with some of these different patterns.

Measurement of Lung Function in Relationship to Work

Measurement of lung function on a day away from work is a poor method of diagnosing asthma in general and occupational asthma in particular. It is often normal in this situation or at least within normal limits. Before and after shift measurements of lung function are also in general unhelpful as the diurnal variation in airway calibre with lowest values on waking and highest values 6-8 hours later are usually superimposed on the working day such that improvement should be expected at a morning or day shift. The most appropriate method of confirming occupational asthma is by measuring peak expiratory flow rate 2 hourly from waking to sleeping over periods of work exposure and periods

Figure 1 : Prevalence of work related respiratory symptoms in engineering shop workers showing increasing symptoms with increasing exposure to soluble oils and generally increased symptoms in the workers exposed to mineral oil aerosols.

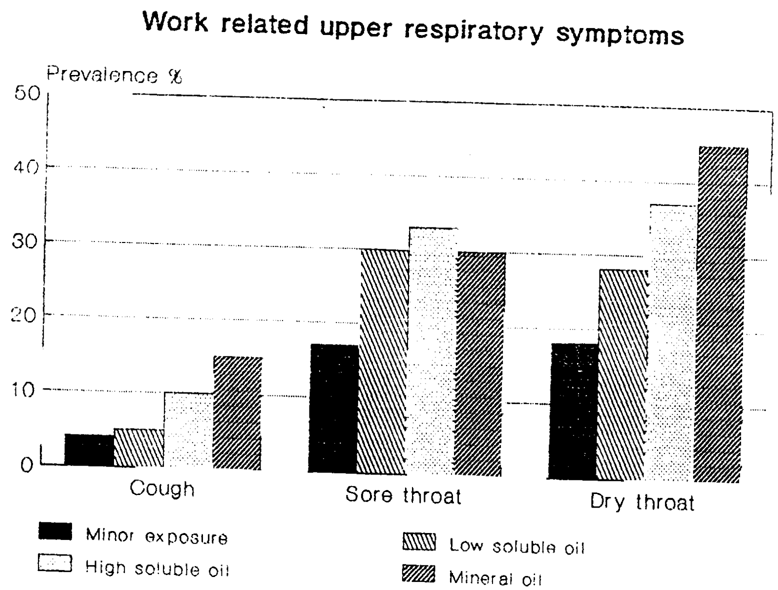
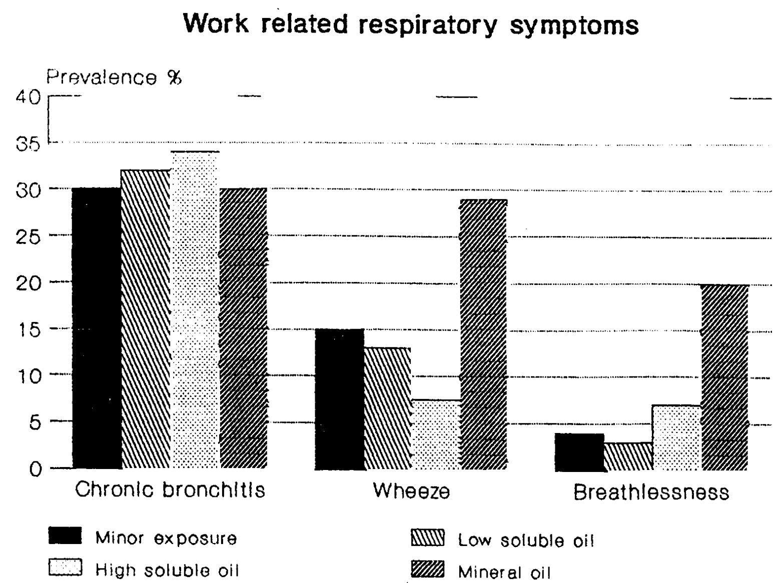


Figure 2 : Prevalence of work related respiratory symptoms in the same workers as in figure 1. Chronic bronchitis was common, but did not increase with increasing exposure to soluble oil aerosols. Wheeze and breathlessness were more common in workers exposed to the mineral oil.



away from work. Using such methods we have found definite work related changes in 13 out of 25 workers investigated who were exposed to oil mists, (Robertson et al, 1988). The asthma may be progressively worse each day at work with improvement over the weekend. This is the most common form of occupational asthma and is generally seen in those with specific hypersensitivity to a particular agent being inhaled. Figure 3 shows such a reaction in a worker who was found to be sensitised to the pine oil constituent of the oil mist used as a reodorant (Hendy et al, 1985). Equivalent daily deterioration is less often seen and occurs in two situations, either when a worker fully recovers between each days exposure, or when a substantially fixed element of airways obstruction exists, such as with continuing exposure. Interestingly the worker shown in the previous figure developed an equivalent daily deterioration pattern after prolonged exposure (Fig. 4). It was only following the engineering strike of 1981 that he was well enough to show the more classical progressive deterioration pattern shown in the previous figure. Equivalent daily deterioration may also result from an irritant effect known in pre-existent lung disease such as severe obstructive bronchitis.

Some workers have reactions which are most severe on the first day of exposure and improve despite continuing exposure, or sometimes are worst mid-week with improvement towards the end of the week. Such a reaction is shown in figure 5. The record starts with a two day period away from work with a mid-week deterioration followed by substantial improvement on a one day period off work, followed by deterioration which is maximum on the first day of the next working week. Reactions that are worse either on the first working day or mid-week and will improve despite continuing exposure are rare in allergic asthma but are the type of reaction classically seen in Byssinosis in the cotton mills. There is some evidence to suggest that the mechanisms are different in this group and may be related to microbial contamination of the environment. Cutting oils frequently become contaminated with many bacteria, and endotoxin levels are increased in this situation. Endotoxin is a possible cause of such reactions. It is interesting that the above worker reacted on challenge testing only to used soluble oil and no reaction to the clean soluble oil, nor to the mineral oil to which he was also exposed. This would further substantiate the effect of microbial contamination, although clearly there are other materials which contaminate the used oil, including materials derived from either the cutting tool or from the piece being worked.

The methodology of serial peak flow measurements in relationship to work have been described by Burge (1982). These measurements are specific but not very sensitive. Finding asthma unrelated to work on serial peak flow measurements with short periods away from work between work periods, should not exclude the diagnosis of occupational asthma.

Bronchial Provocation Testing

There are substantial problems in bronchial provocation testing with soluble oil aerosols, which have not yet been solved. In the work situation the exposure is to an aerosol which is formed by spraying the oil onto a fast rotating piece which is hot. It has not been possible to reproduce in the challenge chamber the flash heating and aerosol components of the exposure at work. The constituents of the oil mist exposures at work are also extremely varied, and most workers are exposed to aerosols from several different soluble oils. Bronchial provocation testing in theory offers the only way of differentiating between the different components of the oils which may be causing the reactions. To date, bronchial provocation testing is only finding the specific cause of occupational asthma in the minority of those tested with oil mist exposure. The first worker reacted to the pine oil reodorant which was volatile at room temperature (Figs. 6 and 7). It is therefore likely that the causes of occupational asthma in oil mist exposed workers varies and that both the individual constituents of the oil and contaminants during oil use are relevant. Dyes, biocides, reodorants and emulsifiers are more likely to be the cause of reaction in unused oils than the oils themselves.

Figure 3 : Daily maximum (top line), mean (middle line), and minimum (bottom line) peak flow in a toolsetter exposed to oil mists. The days at work have a stippled background, the days away from work a clear background. There is progressive daily deterioration during the first work week, with recovery during a three day break, with further deterioration during the next two days at work.

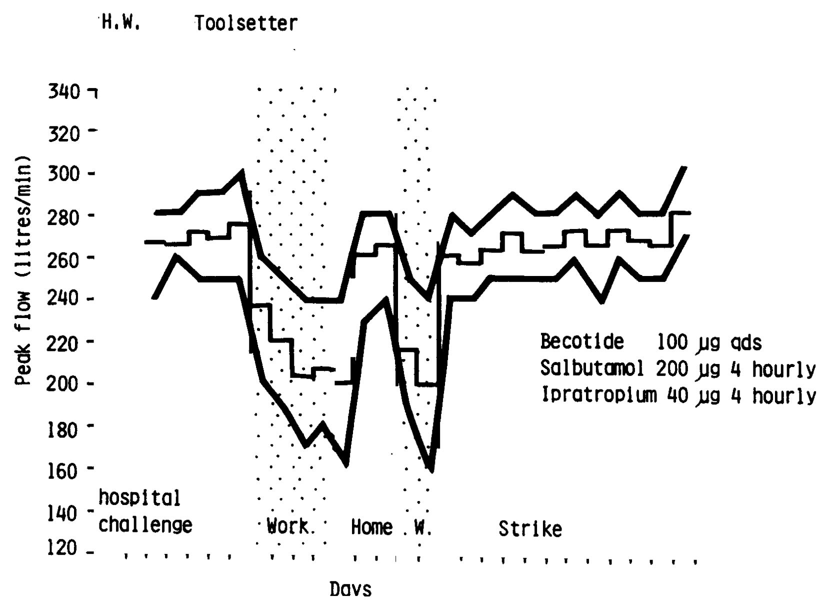


Figure 4 : Serial plot of peak flow as in figure 3 in the same worker after a prolonged period at work. His asthma is now much more severe with lower peak flow readings. There is equivalent daily deterioration with only very partial recovery on days away from work.

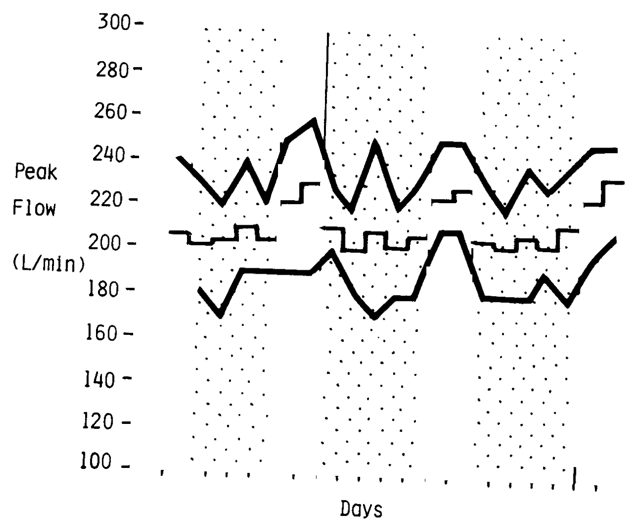


Figure 5 : Serial plot of peak flow in a worker exposed to soluble oil aerosols from a neighbouring bar grinder during the first two weeks, and exposed to mineral oil aerosols only during the second two weeks. There is midweek deterioration in the first work week, recovery on the one day off work followed by first day deterioration in the second work week. There is no asthma when exposed to mineral oils only. Bronchial provocation testing showed reactions to used soluble oils only, suggesting that microbial contamination was the cause for his asthma.

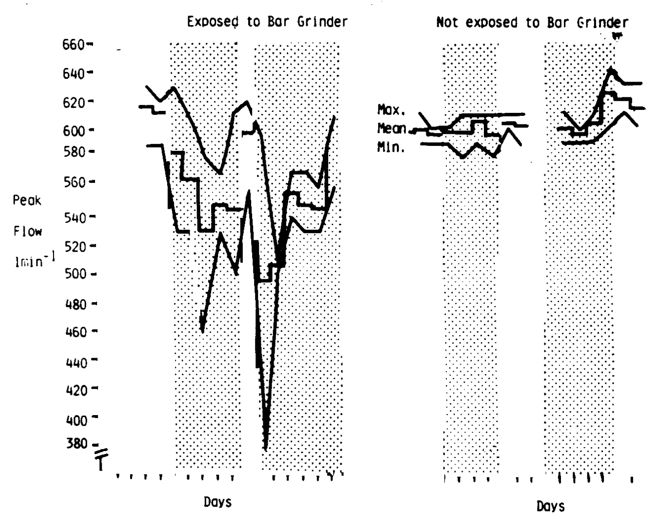


Figure 6 : Bronchial provocation testing to a soluble oil. Exposure was by stirring in a beaker with exposure to the volatile component only. There was an immediate reaction following exposure, with no reaction to a control (hard metal dust) exposure. The cause of the reaction was shown by further testing to be due to the pine oil reodorant. (Fig. 7).

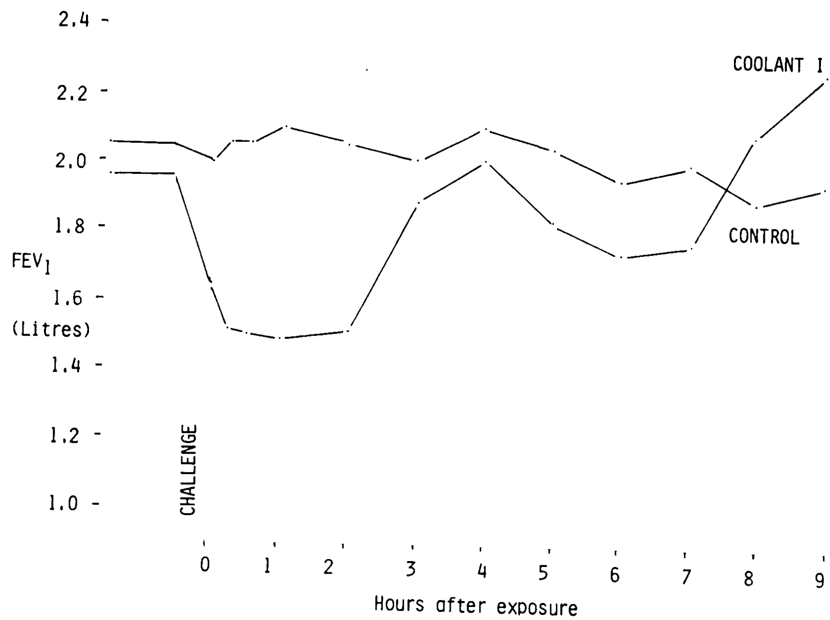
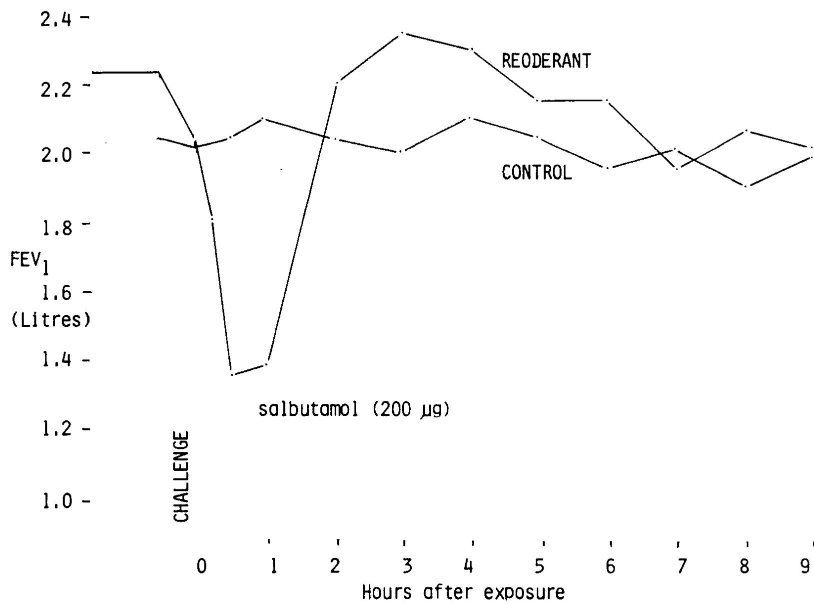


Figure 7 : Bronchial provocation testing to the pine oil reodorant as in figure 6 showing an immediate asthmatic reaction.



So far, immunology has not been helpful in the differentiation of the causes of occupational asthma from oil mists. Specific IgE antibodies are readily found to whole protein allergens such as grass pollen and house dust mite in a domestic environment, and flours and animal danders in the occupational environment. They are less useful in asthma due to smaller molecular weight chemicals which may not always be related to IgE sensitization.

Summary

Current evidence suggests that airways reactions are the major respiratory problem with occupational oil mist aerosol exposure. It is likely that individuals become sensitised to different components of the aerosols, leading to occupational asthma as the most important disease. This may be due to constituents of clean oil, or to contaminants of used oils. Some used oils are also capable of causing irritant effects to the eyes, nose or throat, and exacerbation of pre-exisiting airways disease. These effects occur at levels of exposure well within the current exposure limits.

All mineral and soluble oil supplied should have a complete list of their contents readily available. Microbial contamination should be reduced and exposure levels further reduced.

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Questions

Mr.A.J.Riley British Petroleum Occupational Health Centre. Is there any link between those chemicals which give an indication of respiratory problems and those which also cause occupational dermatitis?

Dr.P.S.Burge I don't know the answer to that, we are going to hear from Richard Rycroft about dermatitis and the last time I heard him, which was many years ago he was very keen on the microbes being mainly responsible, is Richard here yet? No. Lets hope he comes quickly but anyway can you ask him that. But I think there is, that he thinks or did think anyway that the major dermatological problem was from an irritant effect brought on by microbial contamination, and I think microbial contamination is responsible for probably about a quarter of the occupational asthmas from oil mists that I see. Colophony is in everything it really is or bits of pine oil and I think that is one possible cause, but there is such a range of things and if people start inhaling chemicals which they are undoubtedly going to do in this industry then there is going to be probably the odd patient who gets sensitized to almost anything.

Dr.P.C.Elms Cardiff. Are reodorants such as pine oils just cosmetic to make things smell nice?

Mr.P.J.Ruane If you notice when I put the overhead up I subdivided them into scents and reodorants. Scents are definitely cosmetic and by scents, I mean those such as flower fragrances included purely to give a nice smell to a particular product. Scents do not tend to be used a great deal in the oil industry because odour is so subjective. You can get a situation where people in one factory like pine smells and in another factory hate them. Reodorants are used purely to mask a particular smell inherent in a product such as that which occurs when a sulphurised fat is present which has a hydrogen sulphide smell. In operation the product may be heated to higher than ambient temperature so you get a perceptible unpleasant odour from the actual oil. Reodorants can be very effective in that context as a mask.

Dr.Elmes I was just going to make the general point that you have got to be very careful with just putting things in for a cosmetic effect. Looking at the cosmetic industry you will probably have noticed or perhaps your wife has told you that there is an increasing sale of scent-free cosmetics for this very reason. Pine oil or colophony gets used in most of these things just as a cosmetic and this is a danger we have got to avoid or can be easily avoided as long as people know the reason why.

Mr.Ruane Regarding colophony, pine oil in fact is not always used as reodorant. There are certain products on the market that use pine oil as a coupler, particularly in emulsifiable oils. However they tend to be rather rare now. It is fair to say that there is more resistance to the smell of pine oil than there used to be. Pine oil was universally acceptable as a reodourant, but that tends not to be the case any more. Regarding colophony, it is generally associated with products derived from pine woods and can be a component of materials such as tall oil. Fatty acids for instance which are widely used as an emulsifier. The levels may be very small but even so it would be present in materials other than in reodorants.

Dr.J.S.Gardiner ICI Fibres. I would like to ask Dr Burge if he knows of any evidence of pulmonary fibrosis ensuing after exposure to atmospheric oil?

Dr.Burge There is one paper which I wrote a long time ago and I dismissed as being, the evidence was not there, I can give you the reference of one or two papers but I think that the medical evidence is extremely doubtful.

Mr.E.C.Hill Cardiff. You showed a slide from Bengt Jarvholm of the increased immunoglobulin level and you have suggested that in some cases micro-organisms are the factor there, have you actually looked at the serological aspects by looking for antibodies specifically.

Dr.Burge No. I'm not suggesting that the microbial contamination is the cause of the IGM rise, the immunoglobulins have been looked in quite a lot of causes of occupational asthma and the only one they have been raised in, is in colophony asthma in the electronics industry with no microbes at all and the specificity of that was unclear because we cannot actually measure antibodies to colophony because we have not got the protein binding to make complete antigens out of it yet, but one of the problems is to know what microbes to look at because certainly in my side of things I find great difficulty in growing things apart from Pseudomonas and some of the common medical type organisms as opposed to some of the ones you would be growing.

Mr.S.Bryan Rods Oils. Could I ask our last speaker whether he can put a percentage to the number of people who have occupational asthma in the working engineering population.

Dr.Burge Not at all, my study of one place in Coventry has not demonstrated unequivocally occupational asthma there at all, although there are some throat and eye symptoms, the Jarvholm ones did not try and specifically identify occupational asthma so I don't know. I think its going to depend on the contamination and I think its going to depend on what is actually in the oils at the time, and that is such a variable feast that it is very difficult to know.

Mr.S.Bryan My question is to gauge whether there would be a situation where the number of people who suffer from occupational asthma would be people who would suffer from that regardless of the cutting oil or would be more prone to that sort of asthmatic condition whatever their working environment would be.

Dr.Burge I think that somebody with underlying asthma is more likely to develop occupational asthma and somebody who has asthma at the start of an employment would be at excess risk of getting a new sensitization to most forms of occupational asthma. The ones that I have told you about are all people who have developed it for the first time with oil mist exposure. We looked at one of your oils actually and I didn't think it caused a reaction in anybody.

Mr.R.J.Reynolds Health and Safety Executive. I'm not surprised that Dr. Burge should have found that the number of people who suffer from occupational asthma is greater for oil mists than for isocyanates because I suspect there are many more people, a bigger population who are exposed to oil mist and also the people who are exposed to isocyanates generally use, in fact they have to use respiratory protection, if they don't and the factory inspector goes in and sees them working, for example paint spraying, with out proper protection there is likely to be a prosecution resulting. I would like to know your view as to whether you really think that oil mist is a more potent agent than isocyanates, I really don't think it is myself.

Dr.Burge I think that it is very unlikely that they are as potent as isocyanates, all I'm saying is just in my practice I identify more of them and clearly the base from which they come may be vastly higher. This is something new and the first person we reported with occupational asthma was only three years ago, that was the first individual who I mentioned who stirred this stuff. I think this is the part of the world where we ought to be able to try and look at the problem because there is such a lot of oil used.

Dr Holland-Elliott GEC Trafford Park. Can I ask what your indication is please for provocation testing?

Dr.Burge The indications for provocation testing are first of all having the resource to do it and I don't really have the resource with oil mist because it is too complicated. We should try however when somebody's livelihood depends on finding the precise cause. It is likely that the solution to this is going to be substitution of the offending agents out of the oils and for that you have to identify the cause. It's no good just showing it's the cause for one person you have got to show that it's the case more widely than that. I think there is a definite place for provocation testing for some patients. But unfortunately its really too complicated for the resources that we have. We need some help in trying to do this to get the exposures correct, but I don't think there is an indication just for the sake of doing it, but if somebody is going to lose their job and be made redundant otherwise. I think there is a good indication for doing them.

Mr.Riley BP. Picking up on the point made by the gentleman from the Health and Safety Executive that oil mist is not as great a problem as isocyanates, I agree. With isocyanates the occupational exposure is a lot lower than it would be to oil mist in the slides that you have shown there was a considerable amount of oil mist in the work environment and therefore potential for inhalation. Do you think that there are grounds to decrease the exposure limit or bring the exposure for oil mist down on the grounds that there may be a problem with occupational asthma?

Dr.Burge I think that is a bit premature I would think that in general you need to get it as low as you possibly can as the rules say. I think my paper is the only one on occupational asthma at present and I think that it's jumping the gun a bit but I think its worth it. If you are looking at people with oil mist exposure what I'd encourage your occupational health services to do is to be aware that this might be affecting the lungs and to have a look and see if you have a problem in your work place, specifically with increased respiratory problems, low lung function or asthma. Then I think you need to reduce your exposures or else change your oils.

Dr.H.R.Kemble Ford Motor Company. First of all, a plea to workers in the field, to tidy up the nomenclature of the oils they are talking about. The first speaker did point out that there were definition problems when it came to the synthetics and the semi synthetics. What did Dr. Burge measure in the environment when he did his investigation?

Dr.Burge Debbie Glass measured some of them and she is behind you so perhaps she could answer that at the Coventry factory.

Ms.D.C.Glass Institute of Occupational Health We measured total oil mist in air, according to the standard method with cyclohexane extractables we did not actually look at any of the constituents.

Mr.M.Piney Gerry Lee, is going to talk about measurement and the problems of measurement tomorrow. We have heard today how complex oils are and I think he will touch upon that.

Dr.Burge The factory where the worker was exposed to both the mineral oil and the suds the hygienist there did actually differentiate between exposures to one and the other, and the suds exposure on a personal sampler was said to be about 0.5 milligrams per cubic metre and the mineral oil about 1.5 mgm. I dont know how he differentiated them.

Mr.H.Krebs Hankel Dusseldorf in Germany. In the first presentation it was pointed out that even nitrite free products containing alkanolamines can produce nitrosamines do you have any hints for the audience to reduce even this building up of nitrosamines.

Mr.Ruane I would say the obvious answer to that is to have products that are alkanolamine free or certainly free of alkanolamines that produce nitrosoalkanolamines which are likely to have a real carcinogenic risk. Having said that its rather easier said than done. One of the difficulties in this sort of work anyway is that, as far as I am aware, there is no perceived threshold of no risk for nitrosamines so if you have a situation where you have 1ppm in the coolant you are not in a position to say that coolant offers no risk. In practice it seems very unlikely that it does offer a risk but at the moment it is difficult to actually say that such is the case. It is quite possible to produce products that are alkanolamine free having said that, a move to alkanolamine free products would involve moving away from current machining technology which requires products containing alkanolamines. Its a difficult situation which is not really being helped by some of the advice thats being given on nitrosamines which is, to say the least, a little indistinct in terms of what their actual risk is perceived to be.

Ms.Glass IOH I believe HSE are producing a guidance note on nitrosamines in cutting fluids.

Mr.Ruane There is one already. Actually I make reference to it in my paper tomorrow which discusses nitrosamines. I would say that particular guidance note is not much help because it says things like "it may be regarded as a possible human carcinogen".

Dr.Burge What do you want? Do you want to say it is definitely carcinogenic?

Mr.Ruane Yes. That would be a definite help.

Mr.Krebs In the second presentation it was pointed out that cobalt could cause occupational asthma. Do you have any hints on how to reduce cobalt dissolving into coolants?

Mr Ruane I take it here we are talking about water miscible coolants, yes I do. There has been quite a bit of work done on this in the last eight or ten years. It is not possible to reduce cobalt pick up from hard metal completely, particularly where you grind the hard metal pieces to make tool inserts for instance. That is because pure water, even de-ionised water used in this context does actually pick up some cobalt. What is possible is to eliminate materials which are actually accelerators in this context. Certain alkanolamines are a good example, in that they greatly increase the rate of pick up into the coolant. Several companies are producing coolants which have been shown to produce a relatively low level, which does not increase further despite extended use. That level at the moment seems to be in the region of around 40 to 50 ppm cobalt but if you compare that to some of the levels of cobalt you can reach with particular synthetic fluids I've seen instances of over 800 ppm of cobalt in emulsions, I would say at least that is a step forward.

Unidentified speaker Was that in grinding hard metal or using a hard metal cutting tip?

Mr.Ruane That is actually producing the hard metal inserts for cutting tools. For people who are entirely unaware of this subject, in this context hard metal is usually referred to as the material made by bonding tungsten carbide powder in a cobalt matrix. The tungsten carbide is unaffected by the actual coolant but cobalt from the matrix has a tendency to dissolve.

Unidentified speaker I think what I would like to know is, whether there is a danger of cobalt getting into the aerosol when you're cutting with a hard metal tip, metal which does not contain cobalt.

Mr.Ruane I would think in terms of risk thats considerably lower than where you are actually directly machining hard metal.

Unidentified speaker. Well obviously yes.

Mr.Piney If I could add something there, again I would ask that question of Gerry Lee because I think he has some experience of that in the plants which he is responsible, he's on tomorrow so I would ask the same question again.

Mr.Ruane There is quite a bit of information that suggests that solubilised cobalt within coolants is actually a contact allergen. I'm not sure if Dr Rycroft has done some work on it.

Dr.A.C.Fletcher Birmingham University. A few years ago I heard an account and unfortunately I do not think it was documented, of a machine shop where there appeared to be an epidemic, a large proportion of people off sick with what may have been diagnosed as asthma or a acute bronchitis at the time. After some argument about what it might have been in the end the coolant fluid, the suds oil was removed steam cleaned and replaced and the epidemic or the large proportion of people off sick subsided. This appeared to be a natural experiment implying a microbial contamination, in the same way as people away from work because of a strike etc show a subsidence in symptoms. I was wondering if you had any better documented cases than this, perhaps apocryphal story, that would confirm that sort of situation.

Dr.Burge No, the three people I've got who are worse on the first day of the week and particularly the one I showed you, one of the reasons they may be worse then is that that particular factory was not used over the weekend and the coolant was stagnant during that time and the microbial growth was much greater when the stuff was stagnant and often there was a terrible smell when it was first started up on a Monday morning. In fact he was worse when he was on an early shift, on a six to two on a Monday, than when he was on a two till ten when it had been running for a bit. I don't think that is the whole cause and I think that with some of these microbial aerosols actually you do become tolerant to them very quickly, and you actually require a period off work to produce the symptoms, and the answer is obviously to work over the weekend!

Mr Piney Dr Burge, what research do you feel needs to be done into the problems of occupational asthma due to oil?

Dr.Burge I think there needs to be a team who understands about oils and I unequivocally as you will discover don't understand about oils, I understand about occupational asthma, but what I need to work with is somebody who can actually look at the situation, look at both the microbial contamination and look at the constituents of the oil and start measuring things in the air, then we basically need to go and start off with cross sectional studies in a number of different places, preferably places which are working with a very limited number of oils and where some of that is in the air. We need to look at places where there is high levels in the air and places where there is low levels in the air and see if one place has more problems than another. Thats I think will be the next stage which is relatively cheap certainly by rat and mouse and injecting things into them standards, thats very expensive, much cheaper than that and you have actually got people who are exposed so I would go for looking at the humans first and look at a range of exposures, using mixed teaming including oil chemists, hygienists, and doctors who understands about occupational asthma.

INTRODUCTION TO MICROBIAL CONTAMINATION OF CUTTING OILS: ENGINEERING AND HEALTH IMPLICATIONS

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Many hundreds of different microbes have the ability to utilise oils and oil additive as nutrient and energy sources and hence can grow and reproduce in cutting oils (1). Microbial populations of up to 10^9 per ml are not uncommon and are responsible for chemical, physical and functional changes in the cutting oil formulation. Water is essential for active microbial growth and hence oil emulsions, and synthetic and semi-synthetic aqueous dispersions are often ideal environments. Straight cutting oils can only support active microbes if they are significantly water contaminated. In many modern metalworking fluids the oil component may be partly or completely replaced by other ingredients.

Severe infections are recognized by objectionable smells, discolourations, slimes and scums. Functional problems are evidenced by filter plugging, oil emulsion separation , fall in pH, corrosion, wheel blinding in grinding operations, poor surface finish on work-pieces and short service life. There are thus sound economic reasons for minimizing microbial spoilage and in recent years this has been aggravated by the increased cost of down-time, the new oil charge and, in particular, disposal of the old oil charge.

Conventional control measures have involved good housekeeping, re-formulation and the application of anti-microbial chemicals (loosely referred to as biocides). Attempts to use filtration and ultra-violet light to reduce infection have met with little acceptance but in line pasteurization has been investigated and a few equipments built and installed.

Some formulations of metalworking fluids (MWF) have attempted to confer "bio-stability" but this does not mean that they are necessarily actively anti-microbial. In most cases large bacterial populations can be tolerated without obvious evidence of functional impairment. However, in prolonged use these fluids frequently prove prone to massive fungal infection.

Although the Health and Safety at Work Act enjoins an employer to provide a safe and healthy working environment, the health risk of infected cutting fluids is largely a matter of conjecture and opinion. The new "Control of Substances Hazardous to Health " Regulations 1988 includes microganisms as hazardous substances and requires employers to carry out a risk assessment. The Sheffield Trades Union Safety Committee once proposed that cutting oils should contain less than 10^3 bacteria per ml with no pathogens present. This is almost unachievable in the light of present knowledge and practice.

We can postulate (2) that hazards could arise from infected cutting oils due to

1. conventional pathogenic microbles being present.
2. spoilage microbes which are opportunistic pathogens being present.
3. chemical changes induced by the microbes.
4. a serological response due to inhaling infected aerosols.
5. toxin production and release by microbes present.
6. mis-use of biocides or use of hazardous biocides.

These perceived risks would be manifest by inhalation, ingestion and skin contact. The former will be dealt with in a later paper.

Although it is known that urinary tract and faecal pathogens can occasionally be found in MWF and survive there, no evidence available to suggest this is a real hazard.

Skin pathogens do not survive well in MWF and although they must repeatedly "inoculate" MWF systems they do not appear to play a significant role in dermatitis. A much more likely role in dermatitis is the involvement of the opportunistic pathogens, particularly Pseudomonas aeruginosa, as these can destroy the skin structure by virtue of their keratinolytic enzymes and hence affect its permeability to chemical and biological irritants. These same organisms are potent endotoxin producers and these can be expected to invoke a response if introduced into the body. The selection of a biocide must be appropriate not only for its anti-microbial properties but also its toxicology and environmental impact. Some biocides can promote nitrosamine formation. Over-dosing with biocides is itself a potential hazard. This can now be avoided by using an on-site biocide monitor which allows precise additions of biocide to be made to achieve target levels but not exceed them (3).

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DERMATITIS AND CUTTING FLUIDS

Dr. R J G Rycroft - Consultant Dermatologist, St John's Hospital for Disease of the Skin; and Health and Safety Executive, London.

We see hundreds of patients with cutting fluid dermatitis and almost of them work with water-based cutting fluids. We rarely see people in our occupational dermatology clinic with dermatitis from neat (straight) oils. There are various reasons for that, including the fact that neat oils are used less now. When neat oils do cause trouble, it is almost always oil folliculitis or acne that we see, which is cured by better hygiene and not usually a big problem to get rid of from a factory.

Most cases of skin cancer from cutting fluids are related to neat oils rather than to water-based fluids, though there are also some cases from water-based cutting fluids. Another important point about skin cancer from cutting fluids is the latency period, the long time that may elapse between the operative first working with cutting fluids and getting cancer, meaning that many of them occur in retired machine operatives. This often leads to their occupational causation being overlooked, since they may be seen simply as skin cancers of retired men from prolonged sun exposure. The true level of skin cancers from cutting fluids is more than the reported level though they are usually curable. The scrotal cancers have a higher fatality risk and still sometimes present. Dermatitis from neat oils is relatively rare compared with folliculitis, and relatively rare compared with dermatitis from water-based fluids. When it does occur, it is more likely to be from neat oils with a low boiling range. The lower the boiling range the higher the irritancy. Aromatic fractions in neat oils seem to be more irritant than paraffinic.

If you patch test patients with neat oils enough you will occasionally detect sensitization to an additive. It must happen quite rarely because of the scarcity of reports. Those that we have seen in the last 10 years or so have been, first of all, dipentene, which we found sensitizing in a honing oil once, and two instances of epoxides, which are used as scavengers of chlorine ions released from chlorinated paraffins. Unfortunately, epoxides do not always cross-react with our standard epoxy resin patch test. To move on now to water-based fluids. I have never seen a case of folliculitis from water-based fluid. Water-based fluids, have caused much less skin cancer but they have caused a great deal more dermatitis. This often begins as scaling between the fingers, similar picture to that from washing-up or from being a hairdresser. The common factor appears to be contact with surfactant. The dermatitis can then invade the back of the hand and tends to go up the forearms, often seeking out the area where the fluid runs down every time that the arm is lifted. It usually seems to spread in a rather patchy way and some times it is so patchy that it can look like a constitutional form of eczema called discoid or nummular eczema.

Although the surfactant (emulsifier) is the main irritant, one has to consider other factors as well and I will come to these again when we are talking about control. We envisage that, because irritation tends to happen over a prolonged period of time, the irritant stimulus needs to be repeated until the skin repair mechanisms begin to fail. The majority of dermatitis from water-based cutting fluids is irritant. If you patch test such patients they are often negative. But there is a substantial minority with positive patch tests. Irritancy is probably still the primary event in most cases, though sometimes sensitization might precede irritancy. In a recent series of patients attending two patch test clinics with water-based cutting fluid dermatitis, more than a third were found to have a relevant allergy, not always however in the cutting fluid. These are of course a highly selected group of patients and not representative of the whole factory population with water-based cutting fluid dermatitis.

At the top of the list of allergens in water-based cutting fluids are biocides. The commonest has probably been formaldehyde itself, from formaldehyde-releasers, but the releasers themselves can also sensitize, for example certain of the Grotan range. Formaldehyde-releasing biocides also occur in the Bioban range. Sometimes patients are allergic to both formaldehyde and formaldehyde-releasers, sometimes only to one or more of the releasers. Substitutes for formaldehyde have increasingly been used, including the Proxel range, which are also sensitisers. Other sensitisers are in the Kathon range, for example Kathon 886 MW. The concentrations at which such biocides are used in water-based cutting fluids are crucial in determining the risk of sensitization. The lowest levels that are technically adequate should always be aimed at, to minimize the risk. Besides the biocides, the common sensitisers in water-based cutting fluids include colophony (rosin) the base of some of the emulsifiers, MBT, a much rarer constituent of cutting fluids used particularly for machining copper, and the metals nickel, cobalt, and chromium. The levels of these metals in cutting fluids are usually too low to be a problem, but if alloys high in nickel, cobalt, chromium are machined sensitizing levels can arise from leaching-out.

What influence micro-organisms have on the dermatitis remains debatable. We do not think that they normally have any direct effect of the skin because they are not human pathogens. But they may perhaps have an indirect effect by their degradation of cutting fluid making it more irritant. Nevertheless, I have been in factories with highly contaminated cutting fluids but little dermatitis, and in factories with much less contaminated cutting fluids but much more dermatitis.

In a detailed study of machine operatives working with soluble oil that I carried out in the 1970s, about 1/3 of a survivor group, missing many men who had previously contracted dermatitis, still developed some degree of dermatitis from the soluble oil in the course of one year, that is right down to the most minimal degree. Soluble oil dermatitis is therefore endemic, rather than epidemic, and so-called outbreaks are, in reality, periodic increases in prevalence. Of new workers, as many as 2/3 had some degree of dermatitis during their first six month of work, the so-called "green labour" effect.

Dermatitis from water-based cutting fluids is common and it is multifactorial in causation. There are many factors contributing to it: sensitization is only one of them, an important one but not the most important. If we look at the man, the machine and the fluid, the most important thing in the man, over which we have no control, is his individual degree of susceptibility to dermatitis from cutting fluids. This is not a factor that we are able to predict with any reliability.

With regard to protective clothing, plastic over-sleeves can sometimes be helpful. Their materials and design could probably be improved. Gloves are often unusable for safety reasons but, when they can be used, their materials and design also require attention. Barrier cream does not seem to help a great deal, probably because water-based cutting fluids tend to remove them. Sensitization by lanolin in barrier cream very rarely occurs. After work skin conditioning cream does seem to help, but achieving usage of afterwork creams is often difficult. The choice of skin cleanser needs to be a balance between effectiveness, and their adverse effect on the skin.

Systems of work and payment can make a difference to the degree of skin contact with cutting fluid. Psychosocial factors can influence the course of a dermatitis. People tend to get more trouble when they first start the work, the "green labour" effect already referred to, and when you transfer them to a different type of machine. We have seen a few blind persons with severe dermatitis from cutting fluids because of their inability to monitor visually the amount of skin contact that they are experiencing.

To a certain extent the machine cannot be altered. Vertical drills, for example, tend to involve heavy exposure to cutting fluid. The control method of the machine is crucial and increasing computerisation is decreasing cutting fluid contact. Machine designers could probably spend a little more time thinking about their soluble oil delivery systems and how to design them so that exposure of the operative to cutting fluid is minimised. Much could be gained from having sumps that you can clean out more thoroughly.

Turning to the water-based cutting fluid itself, the less irritant a surfactant the manufacturer can use, the better. Technical requirements, however, may preclude some of the less irritant surfactants, such as nonionics. Control of alkalinity is important and biocides can sometimes raise it. The case against metal fragments (swarf) is a very difficult one to prove, but it seems that chafing of fragments against the skin might make the fluid more irritant and that reducing swarf levels might help to prevent dermatitis. The strength of the soluble oil or synthetic fluid mix affects its irritancy. A compromise has to be reached between technical demands and dermatological demands, technical demands usually preferring it stronger and dermatological demands always preferring it weaker. There are now some excellent valves for mixing coolants, which I think work very well, and seem to be helpful to factories in achieving the right concentration. Refractometers can be used to check the strength during use. The concentrations of potential sensitisers, such as biocides, in the formulation need to be controlled by the manufacturers. Any addition of biocides during use needs to be very carefully controlled indeed in the factory

Climatic factors, over which we have no control, do influence the prevalence of dermatitis, the cold dry weather that can occur in February and March being particularly damaging. The essential factory environment, while difficult to talk about, is highly relevant, from the general attitude of factory management to the problem, to the personality of the foreman or supervisor in the machine shop.

In summary, cutting fluid dermatitis is a common problem to which we have some but by no means all of the answers. A joint approach between dermatologists and industry is likely to be the most productive in the future

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Questions

Mr.A.J.Riley BP. Dr. Rycroft, do you believe that there is a safe level of contact allergen or are we in a situation where there will always be a risk if something is allergenic.

Dr.R.J.G.Rycroft Thanks for the opportunity of being more precise. There is probably no entirely safe level at which a biocide is still effective. There are levels at which it will be effective and sensitize only rarely.

Mr.P.Oates Castrol. A question, or a remark to Richard Rycroft regarding formulating a soluble oil with non ionics. There are two reasons that it is not conducted and products not marketed that way. Number one its very very difficult to formulate a soluble oil on non ionics and produce one acceptable to engineering in other words with good corrosion resistance. The second reason is that with non-ionics its very very difficult after use to separate the emulsions, to separate the oil from the water for disposal, thats the problem, its not cost Richard.

Dr.Rycroft Thank you for that clarification.

Dr.W.E.Brooke from Manchester. Like Dr Rycroft I have looked at a lot of tool setters skins only unlike him I spread it out over twenty years and did not try to do it all in one year. One of the problems I see is the man with mild to moderate reoccurring varying chronic eczema as he is a trained man you really can't just throw him out of that job you can find him something else to do, I just wonder whether he is at any increased risk of developing a long term skin problem such as cancer.

Dr.Rycroft I think that there are many people like that, I see them much more in factories of course than I do in our clinic. I think that one is justified in keeping them in their jobs. While there is no increased risk of cancer, there is sometimes a tendency for their dermatitis to become more permanent. But I think that this disadvantage must be balanced against all the other advantages of being able to stay in the same job. Many patients will choose to have a controlled degree of dermatitis to preserve their own livelihood and, as long as this is an informed decision, I think it is a perfectly reasonable one.

Dr.P.C.Elmes Cardiff. We usually move out the occupational asthmatic patients because they get their reactions with falling doses, in other words they become more and more sensitive. What you have just said implies that the skins does not. You were talking about the patchy distribution, is the skin which recurrently gets dermatitis more sensitive than the areas of surrounding skin?

Dr.Rycroft The patches do shift around so that there is not really any immune skin. Some people do deteriorate progressively with continued cutting fluid contact and have to be removed from the job. But they are probably outnumbered by those who are able to continue. Unfortunately, we have no way at present of distinguishing at the outset between these two groups.

Dr.Elmes The group that deteriorated were not the asthmatics?

Dr Rycroft No, we have not been able to find any predictive clinical features. We have to manage patients according to the individual course of their dermatitis.

Mr.C.Packham Reinol-Janet(UK) Dr. Rycroft,you mentioned the use of gloves. Can I make a plea that if gloves are to be used at the very least the work force are shown how to use them. We frequently see more problems caused by the incorrect use of gloves than solved.

Dr.Rycroft Yes that is a very good point, and one that I did not make.

Dr.A.M.Grieve Shell There are three points I would like to make: the first is to support what Dr.Elmes said about respiratory allergens and people sensitized to respiratory allergens I think they should be removed from future contact with the allergen and all structurally related substances I don't think there is any debate about that. There are similarities between respiratory allergy and dermatological allergy but there are also some real differences.The first is that respiratory allergens can kill. Concerning the advice to take people out of their working environment, I respect what Dr. Rycroft says, we ought not to do that too readily but at the same time if we have a problem which is potentially lethal, as with a respiratory allergen we have to address that. I am aware of some cases of people who have been offered by a doctor a form of medical treatment and used it as a prophylaxis for a respiratory allergen. They have been taking inhaled steroids or something like that to prevent the respiratory allergy preventing them from working. In a potentially lethal situation I don't think that is acceptable at all. How then, can we apply this to the dermatological situation? Is Dr. Rycroft aware for instance of anyone who might be giving someone topical steroids in order to enable the patient to continue working with a dermatological allergen? Finally, in the previous and I thought excellent presentation by Dr. Burge he mentioned that with the RIDDOR Regulations the only real way of us collecting evidence of the prevalence of conditions which were occupationally related was if general practitioners or hospital doctors were notifying these cases. Could I ask Dr. Rycroft if he could give us some indication of whether this system works and whether it gives us any feel for the trends in occupational dermatitis?.

Dr.Rycroft Thank you very much once again for asking a question that enables me to clarify something that I said. We do not keep people who are allergic to their cutting fluid working with the same cutting fluid. This would indeed tend to make their dermatitis progressively worse and worse.The group that I consider we are justified in keeping at work with the same cutting fluid are those with irritant contact dermatitis and not allergic contact dermatitis. That is the crucial difference and is really why patch testing is so useful. With regard to reporting, we are currently developing a system, like the yellow card system for drug reactions, for doctors to report occupational skin disease.

Dr.J.Parr NIPA Laboratories. What type of tests would Dr Rycroft recommend that manufacturers of biocides should use to assess the sensitization potential of new compounds and how relevant are animal tests such as guinea pig maximization tests?

Dr.Rycroft I would recommend the use of the guinea pig maximization test, or of one of its acceptable variants. But this still leaves one with the problem of converting a hazard assessment. There is no animal test to determine what percentage of a potential sensitizer in a cutting fluid is going to be relatively safe on the skin. The animal test tells you about sensitization potential, not about actual risk in use. That depends on concentration and degree of exposure.

CANCER AND CUTTING OILS : THE PAST AND PRESENT

J A H Waterhouse, Senior Research Fellow, Institute of Occupational Health, University of Birmingham

Just over two centuries ago, Percival Pott, surgeon at St. Bartholomew's Hospital ("Barts") in London's Smithfield clearly demonstrated an occupational cancer hazard. He is generally credited with being the first to do so, in his paper published in the year 1775. The connection was of course between soot and cancer of the scrotum. In the trade of chimney sweeping it was known as the "soot wart", and it was Pott who recognised it as a cancer. The practice at that time, and also well into the nineteenth century, despite specific legislation, was for a sweep to keep a young boy, (often starting at the age of 5) to climb up the chimneys to dislodge the soot. Almost always the boy was naked and became blackened all over from the soot. Washing, or the use of a bath was a rare occurrence, often at intervals of several years. As the boy grew older he would graduate to be a master sweep, and take on a boy apprentice himself. But his long period of intimate contact with the soot would often lead to the development of a scrotal cancer. Pott considered that the lodgement of soot in the rugae of the scrotum constituted the principal reason for the condition, but as we shall see, that skin appears to be particularly susceptible to hydrocarbon carcinogenesis.

A century later, Volkmann of Halle in Germany, found scrotal cancer as an occupational hazard of coal tar distillers, and paraffin workers. Two years later, Joseph Bell of Edinburgh showed the same cancer in a Scottish shale oil worker. In the early years of this century the same condition, cancer of the scrotum, formed the subject of a prize essay by S.R. Wilson. Wilson traced 35 cases in the records of the Manchester Royal Infirmary, and found 27 of them to be mule spinners. Further investigation, which he pursued, together with A.H. Southam, showed it indeed to be a hazard of cotton mulespinning, and it became known in this country as Mulespinner's Cancer. The change from animal or vegetable based oils as lubricants for the spindles, to mineral oils took place in the latter half of the nineteenth century, and the consequential development of scrotal cancer, with a delay of 20 to 30 years as the latent period of the disease, led to appearance of a number of cases in the Royal Infirmary and other hospitals of that area. It was now clearly linked to mineral oil, and in the 1920's and subsequently, animal experimentation showed the oil also to be carcinogenic in mice. There was in fact a considerable activity in this field especially in the Manchester area. The Home Office set up a Departmental Committee to enquire into the matter, and the Secretary appointed to the Committee was Sidney Henry. Dr. Henry became very closely involved in the whole subject and indeed in 1946 published a definitive book about it. Manchester Corporation also set up locally a Cancer Committee, to look into other aspects also, and in particular the chemistry of the responsible carcinogens. Here the Twort brothers continued their work for a long time, and led to the eventual publication of an MRC Report on "The carcinogenic action of mineral oils: a chemical and biological study".

Dr Henry was a Medical Inspector of Factories (the forerunners of EMAS) and in his book he analysed the death certificates of 1631 cases of scrotal cancer, these being the numbers occurring in England and Wales from 1911 to 1938 inclusive, after certain corrections had been made. He found just under half of them to be due to mineral oil, and rather more than a quarter due to tar and pitch. The remainder included chimney sweeps, a miscellany of other occupations where the nature of the possible hazard was not clear, and finally an unclassified group.

Latent Period:

One of the opportunities that occupationally-induced cancers provide is that of affording an estimate of the length of time required for the cancer to develop after first exposure to the carcinogenic hazard. Since scrotal cancer occurs so rarely - if ever - spontaneously, it is therefore possible to measure the time from first employment to the diagnosis of the tumour in the majority of cases. If we choose to look at mulespinner's cancer from a period when it was still a common occupation in Lancashire, and when also, even for the oldest employees, their time of first employment dated from times when the use of mineral oil had almost completely supplanted animal or vegetable oils for the lubrication of the spindles, we can attempt to estimate the period of latency. Such a time was 1936 and Table I shows an excerpt from the Annual Report of the Chief Inspector of Factories for that year. A total of 562 cases of scrotal cancer among cotton mulespinners is analysed in that table in relation to their years of employment. The minimum period, in the range 10-14 was actually 13 years, and the maximum just seventy years. The median period for the Active group is close to 45 years, a few years later for the ex-spinners and about a dozen years later (than the Active group) for the retired or unemployed. The latent period among these men is therefore a long one.

After the war the old mulespinning machines began to be superseded by more automated devices. As a consequence, some of the men who had been mulespinners may have been seeking employment in the Birmingham region where there was rather less unemployment than in the Manchester region. This was a conjecture put forward by Dr. Miles Kipling, a Medical Inspector of Factories who had moved recently from Manchester to Birmingham. Because of the long latent period he suggested that there might result an increase in scrotal malignancies in the Birmingham area, attributable properly to their former employment as mulespinners rather than to their current occupation. I was running the Cancer Registry for the Birmingham region, and was about to look into that question when I was asked to provide at short notice some figures for the Stokes Case in 1968. This was a test case brought by a trade union on behalf of the widow of a man called Stokes who had died from scrotal cancer. In the short time available it was only possible to provide in a rather elementary way a comparison of the Birmingham region with the South Metropolitan region (see Table II). The South Metropolitan Cancer Registry was the name given at that time to the unit which combined the cancer morbidity data from three health regions, the South West Metropolitan, the South East Metropolitan and the Wessex. It is obvious from Table II that the figures for the South Metropolitan Registry were approximately double those of the Birmingham Registry for population, total cancers, and for two of the sites of the male genitalia; while for the scrotum the ratio was reversed. This suggested we had four times the incidence that South Metropolitan had, and to draw this conclusion did not need very special expertise in epidemiology.

To return to Kipling's conjecture, we looked at the occupational descriptions of our scrotal cases. We found an excess when compared proportionally with a control series, (as well as with the occupational distribution of the Region) of toolsetters, which was also the occupation of Mr. Stokes. There was no evidence of mulespinners or former mulespinners and this persisted when we were able to obtain occupational histories by direct interviews with many of the men, or with their next-of-kin, which we were enabled to do because of a research grant from the Institute of Petroleum.

It happened that the first clear demonstration of a link between cutting oils and cancer in Birmingham was made by Cruickshank and Squire (1950), who found, of 34 scrotal cancer cases seen in the previous ten years, 12 had been exposed to mineral oils, 13 to tar and pitch, and 9 had to be classified as of doubtful origin. In comparing their cases to Henry's series, Cruickshank noted that they were both younger on average and of shorter latent period than Henry's. He attributed these findings to the fact that it was comparatively new industry and he predicted that the numbers of cases were likely to increase in the future. His words were indeed prophetic for it was among this group of bar automatic machines making small parts chiefly for the motor industry, that the cases arose that we reported nearly twenty years later. Furthermore, after this time lapse, both the average age and the average latent period had increased, moving closer towards Henry's figures.

At about the same time, the Thonys, a husband and wife who were both Medecins du Travail in the French Department of Haute Savoie, had found in a period of fifteen years 133 squamous cell skin cancers, including scrotal tumours, likely to be associated with mineral oil. Along the river Arve was the centre of the French industry of a similar kind to that in Birmingham and the workers were known as Decolleteurs. In France, as in most of continental Europe, analytical epidemiology is very difficult to undertake because of the persistence of the Code Napoleon with its excessive emphasis on secrecy and confidentiality in matters medical. Nevertheless the Thonys estimated their rates of skin cancer to be about 36 times that for the whole of France.

Table I

Years of Employment	Cotton Mule Spinners Active	Retired or Unemployed	Ex-Spinners	Total
10-	1	-	-	1
15-	3	-	-	3
20-	13	-	2	15
25-	25	-	2	27
30-	44	1	8	53
35-	71	1	4	76
40-	72	2	7	81
45-	72	7	17	96
50-	67	10	14	91
55-	38	21	9	68
60-	13	10	13	36
65-	3	4	7	14
70-	-	1	-	1
Total	422	57	83	562

Table II

	BRCR	SMCR
Population		
(millions)	4.76	8.22
Male only	2.35	3.88
Total cases of		
Malignant disease (3-yrs)	40,069	77,393
Male Only	20,625	38,697
Total cases of:-		
Testis (3-yrs)	152	292
Penis (3-yrs)	77	139
Scrotum (8-yrs)	113	55

BRCR = Birmingham Regional Cancer Registry
SMCR = South Metropolitan Cancer Registry

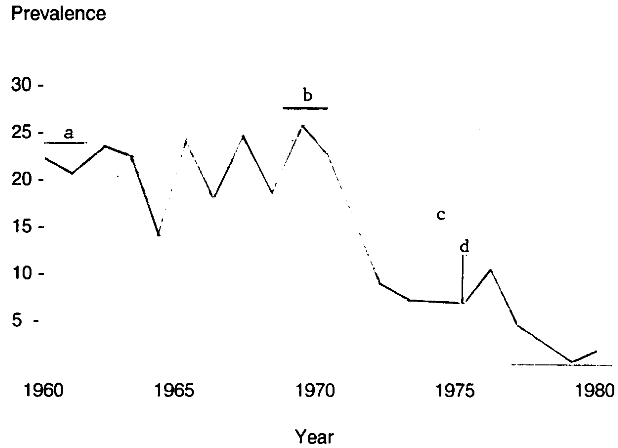
The Scandinavian countries are outside the Code Napoleon and moreover, go even further to facilitate epidemiological studies by their personal number system. Each of the countries has its own variant, but the basic concept is that of a single number for each individual, which includes in a coded form, his birthdate, sex and birthplace. In this country we each have several numbers - one for the National Health Service, one for the National Insurance and another for a driving licence, quite apart from those allocated by banks and building societies. The Scandinavian system substitutes one unique number to each person, which must be used for every purpose, and is quickly memorised. Consequently, follow-up of individuals is greatly simplified, including obtaining causes of death.

A recent publication from Sweden (Jarvholm et al, 1985) describes the finding of skin tumours and premalignant conditions among turners who were exposed to cutting oils in a factory making bearing rings. The factory was founded in 1907 and today employs about 2,500 blue-collar workers, as well as 1000 white-collar workers. Their study was based on 682 lathe operators observed in the 21 year period from January 1960 to December 1980, whose exposure time to cutting oils varied from a few years to more than 30 years. Five skin cancers occurred in this time, four being scrotal and one on the face, and all were squamous cell carcinoma. Compared to the male population of the same city, 0.3 cases would have been expected, so that finding 5 cases was statistically highly significant ($p < 0.001$). In addition, eight cases of keratoacanthoma and five premalignant (senile keratoses) cases were found among the 682 tumours. Among 400 male office workers from the same factory, 375 (94%) of whom replied to the questionnaire, no skin tumours nor any premalignant lesions of any kind were discovered. In 1975 the acid-refined mineral oils that had been used were replaced by solvent refined oils, with a far lower concentration of polycyclic aromatic hydrocarbons (PAHs), and no further primary skin tumours were found after that date. We had experience a similar finding in Birmingham of a sudden reduction in new tumours after the use of solvent refined oils. Possibly the oil may act not only as an initiator of carcinogenesis but as a promotor also, so that although initiated, a growth may not go on to develop as a frank malignancy.

These same authors used the prevalence of oil acne on the forearms of the turners as an index of the general level of carcinogenicity, and the graph (Fig. 1) shows the pattern of prevalence in the period under review. The four events marked indicate possible influences on the level: the first (a) noting a new procedure to remove the work from the machine mechanically rather than manually, thus reducing direct exposure; (b) represents a change in the method of turning , requiring less toolsetting; (c) was the time when workclothes were supplied free; and (d) the change to solvent-refined oils. The curve reflects the effects of these events on the prevalence of oil acne.

In summary, a very clear inference is the importance of registration or notification of malignant skin lesions, especially the non-melanotic. Because of their good survival they do not appear as causes of death, yet they reflect a variety of carcinogenic effects, originating in oils, PAHs, soot, tar, pitch, ultraviolet radiation etc., and may thus be sensitive indicators of new and unsuspected carcinogens. Cancer registries should therefore continue to include all varieties of skin tumours in their catchment.

Figure 1. Prevalence of oil acne on the forearms of turners. The letters show major changes in the work environment. (a = automatic removal of rings, b = new turning method with less tool-setting, c = free supply of workclothes, d = change to solvent-refined oil)



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CANCER AND CUTTING OILS - CLINICAL COURSE, TREATMENT AND PROGNOSIS

Professor M A Cooke- Honorary Senior Clinical Lecturer, Institute of Occupational Health, Visiting Professor Health and Safety Unit, University of Aston, Consultant Chief Medical Adviser to Firmenich and Other Companies,

Lesions which may precede oil cancer are -

1. Dermatitis - irritant or allergic

2. Follicuitis (Oil Acne)

   Occurs at site of contact, eg., forearms, face, legs. Gross secondary infection may occur. Avoidance of contact and adequate washing are essential preventive measures.

3. Shagreen Skin

   Similar to Sailor's skin or Farmer's skin which are precancerous conditions due to ultra-violet light exposure.

   Clinical signs are those of patchy atrophy, pigmentation and liver spots. Photosensitivity may play a part.

4. Warts and Keratoses

   Flat or sessile. May occur in 5-10% of machinists. May spontaneously regress or degenerate into carcinoma.

5. Kerato-acanthomata

   These are difficult to diagnose histologically from squamous cell carcinoma but have reddish haloes. They normally resolve spontaneously in about eight months leaving a small depressed cavity in the skin. A few (about 5%) progress to squamous cell carcinoma. If occurring on the scrotum, should always be treated as carcinoma. Treatment is by excision or curettage.

6. Squamous cell carcinoma

   Appearance may be ulcerative or proliferative. Exposure for at least four and a half years but usually much longer is required. It starts in one of several ways, either as keratoses or flat warty lesions, which may later break down, or as nodular or ulcerated lesions. It is difficult in some cases to be sure of the degree of malignancy in the easily stages and the lesions have to be differentiated from simple warts and kerato-acanthomata. Doubtful lesions are best excised and studied histologically, although the histology is no always or early distinguishable from that of keratoacanthoma.

TREATMENT

Treatment of scrotal cancer is by wide and deep excision. Affected glands should be removed but normal glands are left. If there is any glandular recurrence a month or so later, the further affected glands should be removed.

Treatment of lesions at other sites is by excision and/or radiotherapy.

PROGNOSIS

The prognosis for oil induced cancer of the skin, other than on the scrotum, is good if treatment is reasonably early. Scrotal lesions, about 50-60% of the total, are more serious and it is difficult to give a definite prognosis in any individual case. The poor prognosis, a mortality of more than 50%, and the drastic treatment required, emphasise the importance of fully adequate preventive measures.

Oil cancer of the scrotum

AIRBORNE HEALTH HAZARDS OF CONTAMINATED CUTTING OILS

EC Hill - ECHA Microbiology Ltd, Unit M22, Cardiff Workshops, Lewis Road, East Moors, Cardiff, CF1 5EG,

Airborne health hazards could arise in several ways. Volatile microbial by-products could be objectionable or toxic. For example, hydrogen sulphide has a UK OEL of 10 mgm/m^3 and this is frequently exceeded near spoiled metal working fluids (MWH). Hydrogen sulphide anaesthetises the sensory organs and hence our awareness diminishes. It is more poisonous than hydrogen cyanide and deaths associated with microbial spoilage have been recorded. Sulphide generation is aggravated by stagnation and swarf accumulation.

Metal working operations generate aerosols of cutting fluids. Droplet sizes less that 5 m can pass into the alveoli; they can be demonstrated in the machine shop, particularly near grinding machines. If the cutting fluid is infected, large numbers of microbes can be inhaled. Of most concern is Pseudomonas aeruginosa which is both a common spoilage organism and a known opportunistic lung pathogen. Exposure of laboratory animals to Pseudomonas aeruginosa infected oil aerosols causes rapid pneumonia and oedema; a lesser effect is observed with non-infected oil mists. However, a machine shop survey of 38 men exposed to Pseudomonas aeruginosa aerosols failed to reveal any evidence of respiratory tract infection (1).

It is probable that the viability of the air-borne bacteria rapidly diminishes but inhalation could still invoke a serological response. Such a response is presented in "Humidifier Fever" which is caused by the inhalation of microbial aerosols from air conditioning systems and is typically a "Monday morning" phenomenon. The symptoms are "an influenza like illness, which pyrexia and malaise as the main symptoms, but cough, chest tightness, dyspnoea and weight loss may also be seen." Could there be a parallel in machine shops? "Humidifier Fever", can be confirmed by the presence in the patient's serum of antibodies to the inhaled microbes. We have tested 170 blood samples from workers in four factories for Pseudomonas antibodies. One of the factories did not use metal working fluids and was used as the control. The average titre of Pseudomonas antibodies in workers in the three factories using metal working fluids was significantly higher even though the blood samples were random and did not necessarily come from personnel involved in metal working operations. Pseudomonas aeruginosa was present in metal working fluids in these three factories but not in the industrial fluids used in the control factory or in its air conditioning system.

Animal experiments have shown that the presence of an inhaled oil aerosol enhances antibody response to an antigen inhaled at the same time.

As stated previously, Pseudomonas spp and other Gram negative bacteria are substantial contributors of endo-toxins. The average human tolerance to these is 350 EU and this must frequently be exceeded when infected aerosols are inhaled as 1EU is approximately equivalent to 100,000 Gram negative bacteria (3).

A recent cause for concern has been the colonisation of MWF by strains of Legionella - the causative organism of Legionnaire's Disease. In 1981, 317 assembly plant workers in a Canadian car factory contracted Pontiac Fever, a mild form of the disease probably from the MWF (2).

Micro-organisms are known to accelerate nitrosamine formation in fluids containing nitrites and amines but as yet this process has not been confirmed in MWF Nitrosamines are known animal carcinogens when inhaled, ingested or absorbed through the skin.

As well as the potential microbial hazards we must bear in mind that biocides used in metal working fluids will also be aerosolized and if they are known eye irritants will probably also be lung irritants. Reference has already been made to a technique which monitors their precise concentration. There seems good grounds for a reappraisal of airborne hazards from infected metal working fluids and the decision to use biocides may reflect health concerns as well as operational problems.

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Panel discussion all speakers.

Mr.H.Krebs Henkel Dusseldorf Germany Has Mr Hill any experience of reducing the bacteria number by centrifuge or secondly have you heard about the method that F.N.Freidrichshafen has developed something like an X-ray beam with cobalt 60 to reduce bacteria number? You told us that bacteria gets on the swarf and with a centrifuge you could reduce the content of swarf even the very little particles. Could this be a method?

Mr.E.C.Hill Well I think it does work; the specific gravity of micro-organisms is about 1.05 so if your centrifuge will pull out a particle of that specific gravity, and most of them obviously will and you examine the sludge which comes out of the centrifuge you will find in fact that the sludge does consist of large numbers of bacteria. There are microbial problems in diesel and gas oil etc where centrifuges are run and they certainly pull out a large number of micro-organisms. Although they separate a large number of micro-organisms you are still left with a fair number in the system. As far as electron beam sterilisation is concerned, going back about ten years ago we tried this and found that you killed the organisms by creating active chemical radicals but what the active chemical radicals did to your metal working fluid was completely unacceptable. So we abandoned this project at that time and I don't think we ever published this: there was a paper published in the States and that concluded more or less the same thing. However I understand that there have been new developments in Germany.

Ms.D.Glass Institute of Occupational Health I would be interested to know if anybody had taken any measurements of hydrogen sulphide in the work place because I would be very surprised if they reached very significant levels I believe the odour threshold of hydrogen sulphide is 0.02 to 0.13ppm which is not a great deal. The smell is extremely noxious at 4 to 5 ppm, by 30ppm it smells sweet and by 150ppm you can't smell it. The fatalities have usually been as a result of either a sudden release of gas for example, a chemical in the drains leading to a sudden very high exposure for people in the immediate vicinity or people exposed in confined spaces. I'm not sure if either of these situations would be relevant to factory exposures, I wondered if anybody had actually taken any measurements.

Mr.Hill I completely agree with you, the instances that I know are tank cleaning on ships and things like this in confined spaces. Going back some years (I've forgotten the details) we measured hydrogen sulphide after the MWF emulsions had been stagnant; and immediately you aerate them they will release hydrogen sulphide into the atmosphere. We did quite a bit of work in the laboratory, growing organisms in metal working fluids and measuring the hydrogen sulphide there and this is all in the published literature. For example one of the experiments we did was to run simulation rigs with metal working fluid and we had chemicals which adsorbed and accumulated the hydrogen sulphide so that we could work out how much we produced during a certain period.

Ms.Glass But you don't know exactly what sort of level it was? My worry is that hydrogen sulphide is dangerous at the levels when you can't smell it or when it stops smelling unpleasant; people complain about it when it smells nasty and that is not a good guide.

Mr.Hill I think we only ever once got round to a factory measurement; most work was simulation in laboratory. If you are interested I think I can give you the references, I showed a slide where we were removing swarf and showing the influence that had and if you remember that had sulphide levels on it. We were measuring the sulphide in the fluid and also in the air because we would then gas out the sulphide and measure it in the air.

Mr.A.Coutts Rohm and Haas(UK) We have talked a lot about bacteria and the endotoxins they produce but there has not been much talk today about fungi, fungi are profuse producers of secondary metabolites and a lot of these metabolites are well known mycotoxins I'm thinking particularly with reference to aflatoxins and various other mycotoxins produced by fungi,have any studies or definitive work been done on the toxicity of dead fungal spores or mycotoxins produced by fungi?

Mr.Hill In metal working fluid I would say no. I have asked Dr Rycroft this question after his paper but he has not looked at it. I think we are agreed that it is well worth looking at because obviously mycotoxins are so well known in other situations but I don't believe anybody has looked at them in relation to metal working fluids.

Mr.M.Piney It seems to me we are in the same position we were in 1981, you are saying look there is a lot of bacteria being produced potentially a lot of endotoxin being inhaled, what are the health effects? We are still saying " well, we don't know." I was going to ask you a general question, what research do you think needs to be done in this area?

Mr.Hill I think you are right and we are in the position we were in five years ago. We have virtually made no progress except for recording the facts and wondering what it means. I didn't mention that we had done some animal experiments at Dr. Elmes laboratory through a joint research student and I've got to say that at the end of it all, I wasn't terribly convinced of the results because the poor animals were suffering from the effects of the enormous numbers of micro-organisms, I think we could do more sensible animal experiments to start with and try to get a bit more information about things like Monday morning odour. What is the real sickness element in this? Is it just the bad smell or are people inhaling hydrogen sulphide or endotoxins or what are they inhaling? I think its incredible that we just don't know these things and yet we know that we are inhaling enormous amounts of endotoxin.

Dr.P.C.Elmes Cardiff Dr. Waterhouse mentioned the fact that these scrotal cancers started when they changed from vegetable oils such as linseed or sperm oil to mineral oils and there has been a lot of talk of course about aromatics and polyaromatics particularly as being the carcinogens. There has been a change to oils which don't contain these. Does Professor Cooke think that these cancers, which seem only to occur in people who get the acne, are going to disappear now that the aromatics are taken out of the oils or in other words, are we back to the pre 1870 situation?

Professor M.Cooke I'm not too sure that there is any firm epidemiological data to show what the degree of difference is. As far as animal experiments are concerned, these are fairly conclusive. Solvent refined oils are very much safer than non-solvent refined oils from a cancer point of view. I saw a series of experiments many years ago which the oils were injected into the necks of mice. There was a high incidence of cancers at the sight of injection in the non-refined oils but not from the solvent refined oils. That seemed good enough for me to show that there was a potential difference between the two. There has been a diminution in the incidence of cases, but I would not like to express an opinion on how much is due to the oil and how much to better handling, better machines, or perhaps other factors. I would like to correct one impression that I might have given; I didn't mean to imply that acne was a necessary precursor of cancer or indeed that the cancer subjects are necessarily predisposed to acne in any way. It is only that acne is a marker of over-exposure to an irritant oil. Thereby there is a potential risk following long term exposure of a total population. Some of you probably saw the television programme a few weeks ago in which the use of dirty oils was suggested as a cause of skin cancer. It is interesting that we do not know of many cases of cancer in garage mechanics. We have looked at this with Miles Kipling years ago; he knew of only one case in a garage mechanic. This seems slightly strange because one might have thought they would be a susceptible population in so far as there is exposure to used oil. We were not able to find evidence of this so we hope that that programme a few weeks ago did not start a scare running that garage mechanics are highly at risk - it does not seem that they are. I think I am correct John, in saying we have not got any firm data to answer the question.

Perhaps we should start now because we are about the correct interval after the introduction of solvent refined oils to be able to look for the improvement.

Dr.J.Waterhouse Well I would certainly support that, I support both of the things that Maurice said. We certainly looked at the garage mechanics, very diligently, and found nothing. As regards the change of oils and the reduction in scrotal cancer which I mentioned, I got very nearly to the point of getting support for a study because these things have got to be studied. As you know, they are expensive and they take time, but to get any worth while results one would really want to take all the data to the present time and with fewer cases that is going to make it even harder and to examine them in great detail. I would certainly like to do that, I'd also support what you said about the oil acne because the only paper I can remember that actually looked at previous oil acne was the Swedish one I mentioned, which since they did these regular tests they put down for each of the individuals who developed either a frank malignancy or a premalignant condition whether or not they turned up as an oil acne and it was roughly fifty fifty.

Mr.A.Eastwood Stirling Winthrop What is the panel's view of the levels of acceptance of bacteria found in biostable emulsions, the boron based compounds. It is common for us as a biocide company to find levels of perhaps 10^6 or 10^8or more which may well appear to have no effect on the performance or appearance of the emulsion. Does this not represent a health hazard to the end user?

Mr.Ruane Well I think in terms of health hazard we are back to looking at the results that Ted gave in terms of what are acceptable levels. I think its fairly common and most suppliers of biostable coolants will probably agree that the normal level that you are looking at as a sort of ball park maximum figure is around 10^6 maybe even between 10^6 and 10^7. Essentially depending on the formulation you can actually produce biostable fluids which will run lower levels than these. Additionally you can produce fluids which will run satisfactorily even with levels of bacteria up 10^8. Its very much a question of design of the fluid and the potential application In terms of the actual bacteria themselves posing a health hazards I don't think that we are in a position to answer that question.

Mr.Hill I agree I think we don't know but from a personal point of view I think that its asking a little much to tolerate inhaling aerosols where the fluid contains say in excess of 10^6 organisms per ml I think we are throwing an awful lot of rubbish at the body. Again from a personal point of view if I find very large numbers of Pseudomonas aeruginosa, which is a known opportunistic pathogen I find this unacceptable. So I think we (a) should be a little selective about what we allow there and (b) it just seems unreasonable to me that we should assault the body with enormous numbers of micro organisms.

Mr.M.Piney On this question Ted, it just struck me you together have had a huge amount of experience in dealing with these problems what is the sort of reasonably practicable level of bacteria in cutting fluids, something you can aim keep below or roughly around.

Mr.Hill I think with exceptionally good control 10^5 and to be reasonably practicable its very often 10^6.

Mr.Ruane I think to be honest, its the fact that we cannot give you a straight answer to that question which is probably keeping both Ted and I in gainful employment!

Mr.G.S.Gray British Aerospace Are the biocide monitors that Mr. Hill spoke of commercially available? What is their shelf life in view of the fact the fragility of certain organisms?

Mr.Hill They are commercially available; They can be supplied from my laboratory The shelf life is two years plus, as the organism is a sporing bacillus which is extremely stable.

Mr.G.Worthington British Aerospace We have been using the same types of coolant for two years both biocide and biostable, originally with the biostable I was keeping it down to 10^5 measured with the bio-dip slide now using quite high concentrations, we are hardly keeping the bacteria under control, do you think that bacteria become resistant even at this optimum concentration over a period of time, do they mutate or something?

Mr.Hill I think the answer is almost certainly a population shift because there are thousands of different spoilage bugs if you read a thousand different papers you find a thousand different answers. It is only when I have free labour called students that we can ever look in real detail at the micro-organisms there. We do know that we may have a precise population, say a certain mixture of six organisms which we can identify, and then there will be a change and another six will appear.

Mr.Worthington Would that therefore mean that some bacteria are more resistant to the biocide or the biostable additive than others and the same concentration?

Mr.Hill Well certainly different organisms have much different resistance. If you look at the data sheets produced by all our friends sitting around here Sterling and NIPA etc, they will quote the inhibitory concentration of their biocides against a range of organisms, many of them of no interest to you but you will see that there are quite enormous differences. The fly in the ointment is Pseudomonas as far as the bacteria are concerned; if you can control Pseudomonas you can almost certainly control the rest of the bacteria but not necessarily the fungi and the yeasts.

Ms.Glass IOH In that case your red to white indicator organism is that based on the Pseudomonas reaction or can you only use it as an indication that the biocide is the right strength not that it is actually working for something that you might be worrying about?

Mr.Hill Its an indicator. You mostly know by experience or from the biocides companies the concentration which you should have there and the test tells you that you have got above or below that concentration. We have now had a fair bit of practical experience and we have published a fairly lengthy paper in Esslingen in Germany in January. If you keep the level of biocide up generally speaking you don't run into these resistance problems; it is when you are on marginal levels that you start to get population shifts. I can think of instances now where we get very close control of concentration within clearly defined targets of not above 12ppm active biocide and hopefully not below 6 and this has been going on for years without trouble. Conversely of course there are documented cases of very resistant strains appearing particularly to biocides like formaldehyde but our experience in general is if we keep the biocide at some pre-determined level we don't run into these resistant populations.

Dr.S.D.Robertson Shell Mr Hill's calculations which I surmise were on the back of a fag packet, I think he came up with 10^4 units of toxins plus biocides, was that on the assumption that there was complete retention of the aerosol say in the alveolar region of the lungs or was that a net retention figure? You can inhale particles of say 5 microns or less, I presume you can exhale them as well.

Mr.Hill It was a back of a fag packet calculation as you say making assumptions about the number of organisms which were there and the amount of aerosol which you would create. I agree that the 5 micron figure for inhalable droplets is well accepted (its not our figure) but about the exhalation I just don't know. I can't think of any paper which tells us how much we exhale or whether all is absorbed into the alveolae.

Dr.Robertson I don't know either, that is why I was asking the question. The calculation you have done, without wishing to appear complacent, is the worse case situation.

Mr.Piney I think that Ted's back of the fag packet calculations are the correct way to do it and that the possibility of exhalation is true for sub-micrometre particles it does happen there is a dip in retention in the alveolae but I think that allowing for that it would make little difference to the calculations which are a fair way of doing it.

Dr.Robertson No I wasn't meaning to criticise the calculations, it was as he said himself, informal. Could I possibly ask another question from Mr Hill? I am probably interpreting the data you provided incorrectly but you reported some work done on aerosol measurements of less than 5 microns sampled less than two feet from the grinder, I think you said that there were 33,000 bacteria per cubic metre but as when you went to four feet from the grinding wheel there was a dramatic reduction. You surmised that that could be misleading because possibly most of the living organisms had died. If the particulates were sampled at the same time i.e. either two feet or four feet away from the grinding wheel and if most of the bacteria were dead the implication is that these micro organisms have an extremely short life time.

Mr.Hill We sampled with an Anderson sampler which only measures living bacteria and I quoted one set of figures which are in the literature but you will find that its more or less representative of what we found. I think that there are two factors, one is the poor survival of gram negative bacteria but I agree I don't think this is the only factor as I'm sure that ventilation and air movement were another factor. Once we were four feet away we are in all sorts of air currents, we certainly didn't have a static machine tool with no ventilation; all the normal ventilation was working.

Dr.Robertson Does that not in fact imply that the end user of coolants has a responsibility as well and therefore such things as improved air extraction, expensive as though it may be from a capital investment view point may be necessary if in fact tighter legislation is going to come about?

Mr.Hill I agree. I didn't add, but I could have said, that we did the same work near straight cutting oil machines and I have forgotten what the figures were but we had no where near these high figures and this is what you might expect because microbial infection in straight cutting oil is fairly minimum. I think ventilation is very important.

Professor Cooke I'd like to make a few comments in the context of "what are we really looking for?" It depends who we are and I would not wish to deprecate work which has been done on microbial contamination of atmosphere. I agree with Mr Hill; my sentiments would be that while we should not expose the human individual to avoidable contamination, the human individual can tolerate considerable "dirt" from time to time. The presence of antibodies is indicative of exposure to a specific organism but is not good at telling how the body has reacted to that organism; whether it is for the benefit of the organism to have a high level of antibodies or whether the organism is failing because there is a high level. I am reminded of work in Czechoslovakia; they are looking at immunoglobulins in miners exposed to particulates and also at children with asthma when they are at school or when they are on holiday. They found quite dramatic changes in the immunoglobulins and I think this could be one of the research tools of the future. It could perhaps give us a better idea of whether the body is suffering as a result of this exposure or not. The Monday morning syndrome is not uncommon and there are other causes than organisms. The 'dirty buildings syndrome', treated by some with a certain amount of scepticism year to year is attributed to different causes. It may be a non-specific symptom complex due to a variety of factors. We need to know whether the human organism really suffering and it might be worth keeping in mind the study of immunoglobulins.

Mr.Hill I don't have explanation of it; it just was a fact.

Professor Cooke A very interesting one. The WHO incidentally, have set up a small group looking at immunotoxicology in a series of diseases. Maybe we should consider these aspects.

Mr.A.J.Riley B.P. If I could agree with Professor Cooke there, this is also borne out by Dr. Sherwood Burge's presentation this morning who in his work reported that coughs sore throats dry throats, bronchitis,wheeziness and breathlessness were not related to oil mist exposure but one thing he did say was that the respiratory allergy quite a lot of that was probably due to microbial contamination so that's some evidence that the body is actually coping with a lot of the microbial contamination but can't cope with the protein molecules and you are actually getting allergies as a result of that.

Mr.Piney Can the speakers summarise from a microbiological point of view the companies that get it wrong, what do they do? You must have come across it again and again and you get a sort of standard pattern things to do that will mean you have problems either health or machine problems.

Mr.Ruane Well I think good housekeeping is the most important single factor. Biocides are the second line of defence or perhaps even the the third. It is good housekeeping to start with, and in particular thorough machine cleaning that differentiates the good companies from the bad. Don't take a dirty machine chuck the old oil out and put good clean oil in its place. Machine cleaning prevents the carry over of any contamination. Using a decent water supply helps. Don't use canal water as some people occasionally do in the Birmingham area. Every aspect of good housekeeping has a part to play.

Mr.Hill I would just echo that; I would also say that it is well worth while to educate personnel in all these aspects. However good the general housekeeping is, individuals by reckless action can ruin the best of schemes.

OIL AND COOLANT MISTS - ASSESSMENT CRITERIA AND CONTROL

G L Lee - Occupational Hygiene Adviser, Rover group Plc

The cutting and forming of metals with tools and machines and the rapid movement of one surface against another - eg., a journal running in a bearing - are fundamental processes with roots in antiquity. They are all characterised as being exothermic in nature. The quantity of heat generated under modern industrial conditions is sufficient to weld cutting tools to work pieces, produce unacceptable thermal distortion remove the hardness of heat-treated components and cause the seizure of bearing surfaces. Unless some method had been found to remove this heat and to provide lubrication of bearing surfaces, industry as we know it could not have developed and man would not have progressed much beyond the peasant farmer and simple artisan stages. Man the toolmaker would have been severely limited if it had not been discovered that the wooden wheels of the ox cart could be run at speeds on the axle without catching fire, if lubricated with animal fats and oils. Having discovered how to harden metals, the use of cooling water on the sandstone wheel ensured that the hardness was not lost when sharpening the axe, chisel and sword. The early recognition of the importance of coolants and lubricants and their subsequent development made modern industry with its high performance machine tools possible.

The use of coolants and lubricants has enabled the high speeds of the turbine and internal combustion engine to be achieved; to remove large amounts of stock at very high speeds on lathes, milling, grinding and many other machines. Even the simple operation of drilling a hole in a metal plate can only be done rapidly when a copious supply of coolant is applied. The very fabric of our mass production, mass consumption society is made possible by the use of coolants and lubricants.

The potential for exposure to coolants & lubricants

The advantages of using coolants and lubricants are there for all to see. Equally, so are the dramatic consequences of not using them on high speed machinery. The consequences of using the products which constitute the range of coolants and lubricants are that people come into contact with them. There is a potential for exposure.

The oral toxicity of these materials is not generally a matter of great concern. The consequences of skin contact in terms of dermatitis is undoubtedly the major potential health problem with many of the product formulations encountered. Primary irritation and defatting of the skin can occur to varying extents, depending upon the composition of the products and the degree of exposure. However, the use of relatively simple measures to prevent repeated and prolonged skin contact (usually to the hands and forearms), with good personal hygiene and skin care, may eliminate the dermatitis risk, for the majority of circumstances.

Long-term skin disorders such as cancer of the skin and particularly of the scrotum has been a potential for some types of mineral oil based products in the past. The emotive nature of the word "cancer" has ensured that a lot of attention has been paid to the subject. The results of many studies confirm that risk can be kept low by the use of special refining techniques and the adoption of good personal hygiene practices.

Exposure via the respiratory route is the potential which has perhaps attracted the most attention. Workers, medical officers, hygienists and many others have long been aware that coolants and lubricants could be present in air as mists. The inhalation of these mists has given rise to concern about possible health effects and stimulated research and development to try and resolve health enigmas and point the way to obtaining contemporary control standards.

Mechanisms for the generation of oil and coolant aerosols

Two basic mechanisms are identified:-

1. Mechanical atomisation
2. Vapourisation and re-condensation

The rotational speeds of components and machine parts in conventional cutting and milling machines is not particularly high. Bar automatic lathes, for example, often run at spindle speeds of the order several hundred to (say) 1000 rpm. The resultant peripheral speeds of chucks, gears etc, are also relatively low. In most cases, it can be shown that the centrifugal forces involved will be inadequate to generate an aerosol. Such low speed parts of machines are responsible for the splash of coolant which is experienced when splash quards are removed. Commercial liquid aerosol generators used to produce liquid aerosols for respiratory studies and the calibration of instruments usually run at orders of magnitude higher in terms of rotational speed - say 60,000 rpm.

Mechanical atomisation of coolants and oils does occur on some machines. Grinding machines are common examples. Here peripheral speeds are of the order 6000 feet min^{-1} for conventional grinding and 12,000 feet min^{-1} for high speed grinding. Liquid aerosols are freely generated by such machines. Another important means of mechanical atomisation is the use of compressed air. The work done by compressed air jets can readily produce mists by a nebulisation process. A paint spray gun is a classic example. Sometimes oil mists are generated by nebulisation to lubricate air tools-drills, nut runners etc. Oil mist produced by spray jets have also been applied to the lubrication of machine tools.

The most common source of oil mists on machines is the vapourisation and condensation process. It is the same process as that by which natural mists and fogs occur. A liquid is evaporated and re-condenses. In the natural mist and fog, water droplets are involved and atmospheric dust plays a part in providing the condensation nucleus. In the case of cutting oils again the liquid is evaporated, but the boiling parts involved are very much higher - hundreds of degrees celsius. Cutting tip tool temperatures are more than adequate to cause the vaporisation and additional heat energy is present in the workpiece and metal swarf. The re-condensation produces a mist of small droplets. A characteristic of these mists is the uniform, small size of the droplets - usually 1-2 micrometres in diameter.

Assessment of oil and coolant mists

At the particle densities found, coolant mist clouds are fairly difficult to see using the unaided eye, under normal diffuse ambient lighting. Back lighting from a beamed, intense light source, such as the sun from a hole in the building fabric, reveals the presence of the aerosol. It is useful to be able to visualise the release of coolant mists - to see where they originate and how they are dispersed. The Dust or Tyndall Lamp is a useful aid to this visualisation. By observing the most intensively scattered light in the forward direction within a narrow angle to the direction of the beam, the presence of particulates is readily seen. The technique and the associated procedures for recording observations are dealt with in some detail in a publication by the British Occupational Hygiene Society (see references). The essential elements of the method is seen in the following diagram taken from the publication referred to:-

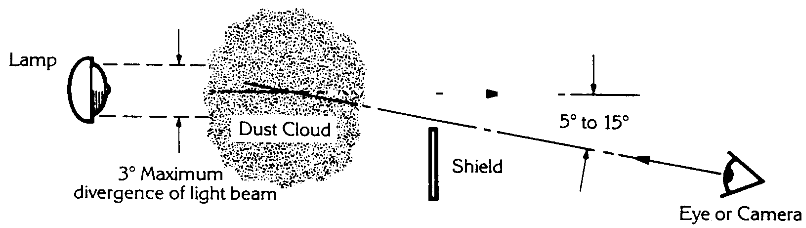


Fig.1 How to position a Tyndall lamp to observe respirable particulate.

1. **Oil Mists**

Useful though visualisation is, sampling and analysis may be required to establish the concentrations of oil and coolant mists. Dealing firstly with oil mists, the most common practice is to draw air through a pre-weighed glass fibre filter and re-weigh after an appropriate sampling period. When the weight gain is less than (say) 1 $mg.m^{-3}$, then further work is not normally justified. Samples can be from static samplers or more usefully, from personal samplers to determine concentrations personal to the worker.

Analysis of collected oil mist samples can be achieved by one of these basic methods:- gravimetric, ultraviolet or infra-red absorption.

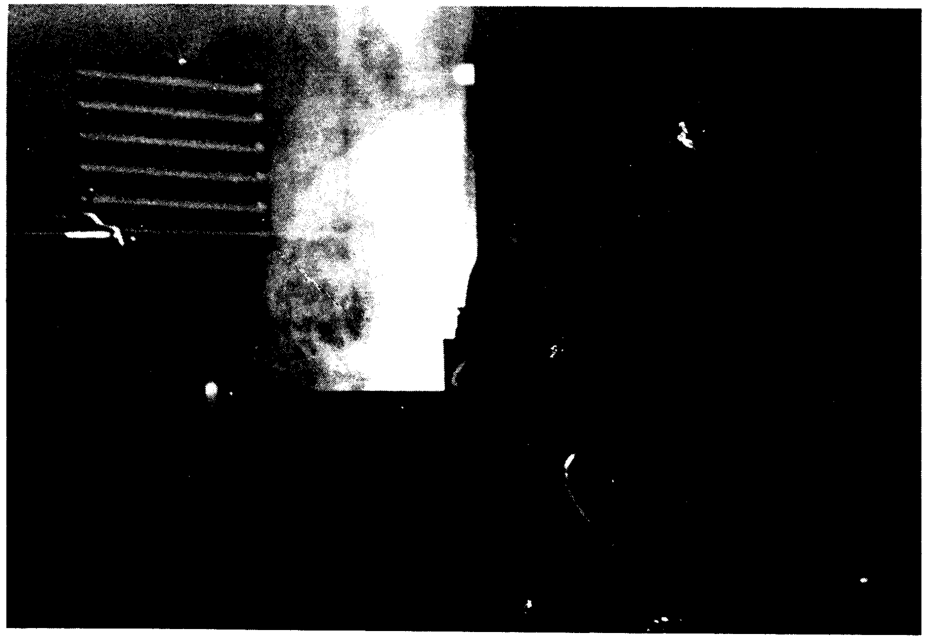
The gravimetric method involves extraction of the oil from the filter using low boiling point solvents, such as dichloromethane, petroleum distillate, hexane, cyclohexene or 1,1,2-trichloro-trifluoroethane. The mass of oil extracted is then assessed by evaporating the filtered extract in a tarred beaker, using an infra-red lamp in a fume cupboard. As long as the oil does not contain significant proportions of readily volatile material, the method is suitable.

The technique can be modified to measure via UV or infra-red spectrometry, n-Hexane and cyclohexane can be used for UV measurement but it has been shown that improved analytical sensitivity is achievable using 1,1,2-trichlorotrifluoroethane. The latter solvent is also safer to use.

For infra-red measurement, extraction with dichloromethane or again, 1,1,2-trichlorotrifluoroethane is the appropriate preparation stage. Absorption occurs in the 3.4 micrometres region.

The techniques have been fully described (see references). The methods are based on development work done by a joint working group from the motor vehicle industry.

It is important to use a sampling method which does not collect vapours. It has been shown that if readily volatile components are present, the collection of even small proportions of vapour can lead to very erroneous conclusions about exposure to oil mists. Acceptable exposures to hydrocarbon vapours are generally at the 10 to several hundred ppm level, ie., several grams per $metre^3$. For (say) C_{10} hydrocarbons, 1 ppm is equivalent to 5.8 $mgs.m^3$. Inclusion of only a few ppm of vapour in the mist collection system will produce elevated results. Thus, adsorbant tube collection is only suitable for vapours.



Figs. 2 & 3 : Use of a Tyndall beam to show oil mist at a hobbing machine

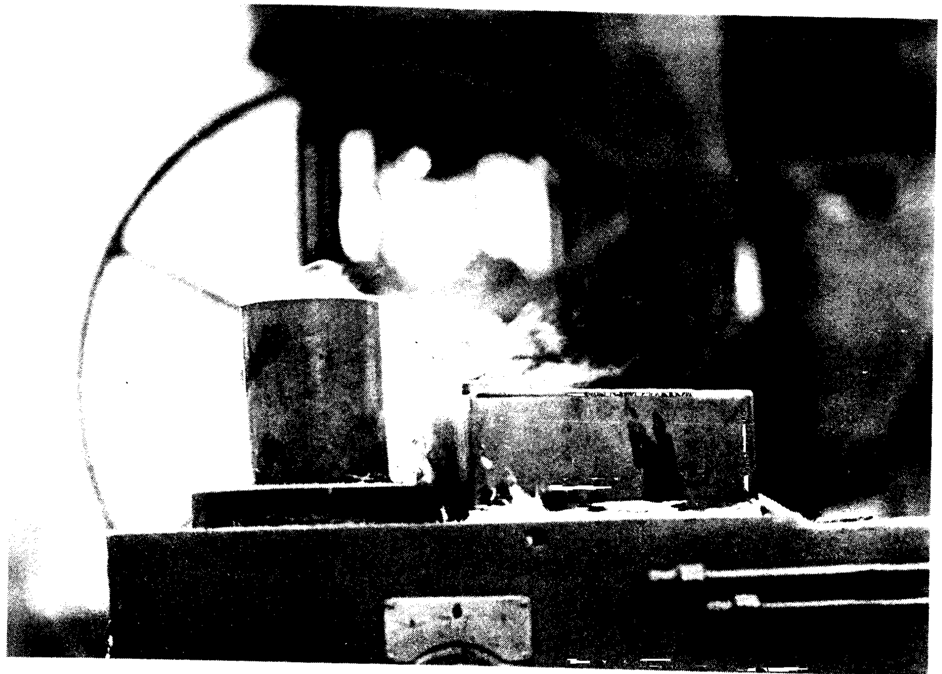


Fig. 4 : Oil mist from milling machine

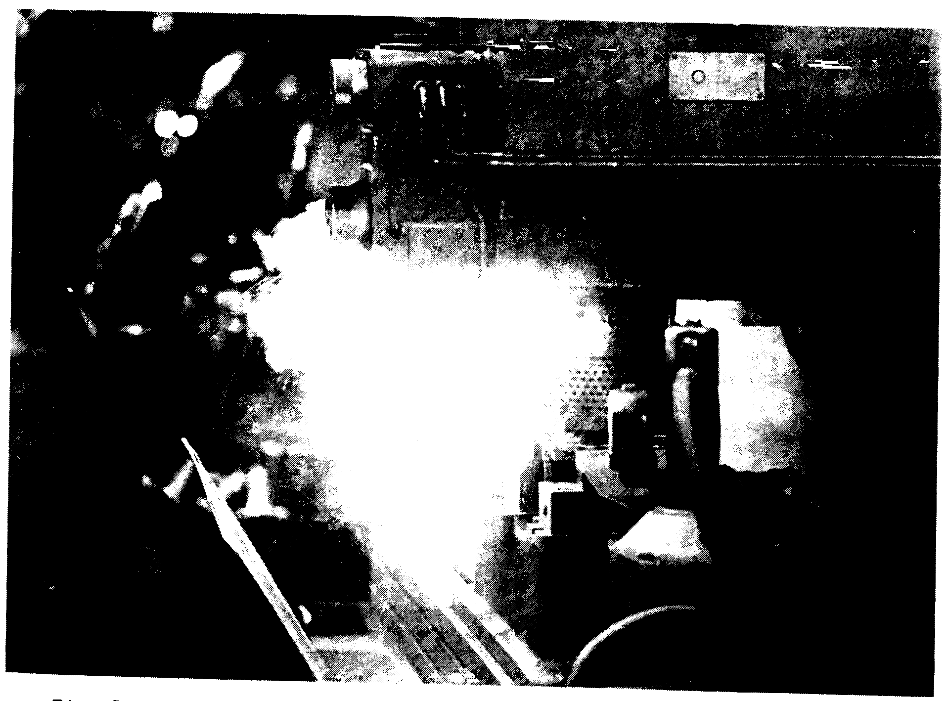


Fig. 5 : Particulates around cutting zone

Spectrophotometry can sometimes be usefully enhanced using scale expansion facilities on the spectrophotometer. Work done inside the motor vehicle industry showed that oil mist in some workshops was largely derived from the lubrication oil used for the machine tools which collects as a "tramp" oil on top of emulsified oil coolants. Differences in the peak absorption values for the soluble oil and the lubricating oil enabled the relative proportion from each source to be determined, leading to controlling the loss of lube oil from bearing seals, rather than the spending of money on extraction.

2. **Water Mix Coolants**

These include emulsified oils (soluble oils), synthetic and semi-synthetic formulations and chemical solutions. The latter could be a simple solution of sodium carbonate in water or a sodium nitrite/triethanolamine mixture in water. These have been widely used as grinding coolants - the objective being to impart post-machining corrosion resistance to ground steel surfaces. In addition to corrosion inhibitors, water mix coolants can contain emulsifiers, such as alkali metal petroleum sulphonates, anti-oxidants, extreme pressure additives and biocides. Some formulations could also include anti-foaming agents and other detergents.

When used on grinding machines, a dense aerosol is produced. (see figs 6 and 7) This is substantially water. If measurements of total airborne, dried particulate or in the case of emulsified oils, oil only, are made then low values will be obtained. Such measurements will not relate to the complaints which can arise in use.

Two techniques have been developed which help in making assessments. The first one is applicable to formulations containing sodium nitrite. The technique is based upon the reaction of nitrites with Saltzman's reagent. The reagent contains N(l-naphthyl)-ethylene-diamine dihydrochloride. Nitrites react to produced a purple coloured complex which can be measured on a spectrophotometer. The method was originally developed for nitrites in waters and later adapted by the Californian Public Health Board for the measurement of oxides of nitrogen in air. Using two bubblers in series, sampling is continued using a fairly high flow rate until the colour in the reagent reasonably well developed. By measuring each bubbler, the collection efficiency can be determined and corrections made for any losses observed. The result is expressed in terms of mgs of sodium and/or the nitrite content of the diluted coolant in the machine. Hence the aerosol concentration can be specified in terms of either coolant concentrate or total aerosol.

An alternative method of assessment is to measure the total sodium present in the aerosol. A conventional sample pump is used to collect the particulate on a filter. An aqueous extract of the filter is then examined for sodium content using a flame photometer. By comparison with the sodium content of the coolant in the machine, the total mass concentration of aerosol is determined.

Criteria

The current hygiene standard for oil mist is 5 mgms.m^{-3}. This is also the American standard and indeed, the criterion was developed in that country, based upon the observations that exposure to oil at that level did not appear to produce demonstrable ill effects, or complaint. However, it is important to note that the observations were with pure oils - largely aliphatic types.

Most cutting fluids contain, additives, such as sulphurised fat, chlorinated wax and various additives such as corrosion inhibitors. Additionally, the base oils are frequently derived from naphthenic and aromatic feed stocks. The net result is a to produce an oil which when present as a mist, is considerably more irritant than aliphatic oil. It has certainly been UK industry experience that a criterion lower than 5.0 mgs m^{-3} is more appropriate. In-house standards of the order 2-3 mgs m^{-3} are not uncommon. The writers's experience is that a level of 2 mgs m^{-3} is a more appropriate air quality standard to use. In Denmark a serious suggestion was made that the air quality standard should be 1.0 mgs m^{-3}, but it was not adopted due to industry insisting that it was not technically achievable without undue cost.

For water based coolants, some "in-house" standards have been 100 mgs, m^{-3} total aerosol, based upon sodium measurements, 15 mgs m^{-3} coolant concentrate, based upon sodium nitrite determination and 0.1 mgs, m^{-3} in terms of sodium nitrite alone. All these criteria have been developed from the incidence of complaints about upper respiratory tract irritation, "taste", sore throats etc.

When coolants are used for grinding operations on some exotic metals, there may well be hygienically significant amounts of metals or metal compounds in the aerosol. The grinding of refractory alloys such as NIMONICS or cemented carbides can produce exposures to nickel, cobalt, chromium and other metals. Analysis of collected aerosols on suitable filters may well be required to assess the significance of exposure.

Control

When oil is mechanically atomised by (say) an air jet to lubricate an air tool or lubricate gears on hand tools, the control to produce the absolute minimum amount of mist needed is important. Metering devices are available which introduce single drops of oil into air lines for atomisation. Certainly when controls are set properly, there are few complaints about taste and odour.

Atomisation to lubricate larger systems such as gear trains over machines are more difficult to control. An excess of oil mist is generally used and the only practical method of control is to use local exhaust ventilation to collect the surplus mist. Fortunately, the practice of lubricating machines using mists is not so common.

Coolant flow dynamics play an important part in determining the amount of oil mist released by metal cutting machines. A common failing is to use high velocity jets to feed coolant to the cutting operation. The high velocity is obtained by reducing the bore of the jet (raising the pressure) which has the effect of reducing the coolant volume flow rate. Oil has a specific heat about one half that of water. Large volume flow is needed to properly quench the heat from tool, workpiece and hot swarf. A number of studies have shown that oil mist emissions can frequently be dramatically reduced by raising the coolant flow on gear hobbing machines, vertical lathes and other cutting machines. One classic study reduced oil mist concentrations in the thermal "plume" above the machine from 67 mgs. m^{-3} down to 0.4 mgs. m^{-3}. (see figs 8 and 9)

Increasing coolant flow is also of value when water based coolants are used on cutting machines. The machining of flywheels and brake drums for motor vehicles is a good example. Visible mists were completely eliminated by attention to coolant flow. Sore throats also disappeared and considerable capital on local exhaust ventilation was saved.

When grinding operations are undertaken with water based or indeed, with other types of coolant, the release of coolant mists is inevitable. Some grinding machines direct aerosols to the rear of the machine. Since the lifetime of a 2 micrometer water droplet is only 0.18 seconds at ambient temperature, dispersal of the aerosol may well occur without problems. Other grinding machines direct coolant aerosols towards the operative and complaint is much more likely. The use of local exhaust ventilation is the only practical approach. Machines using straight cutting fluids, such as thread grinders and gum reaming machines, generate oil mists which can only be controlled using local exhaust ventilation.

Coolant maintenance is an important factor. In use, water based coolants can increase markedly in concentration - especially on grinding machines. At a concentration of 1 part coolant in (say) 50 parts of water, upper respiratory tract irritation may well not occur.

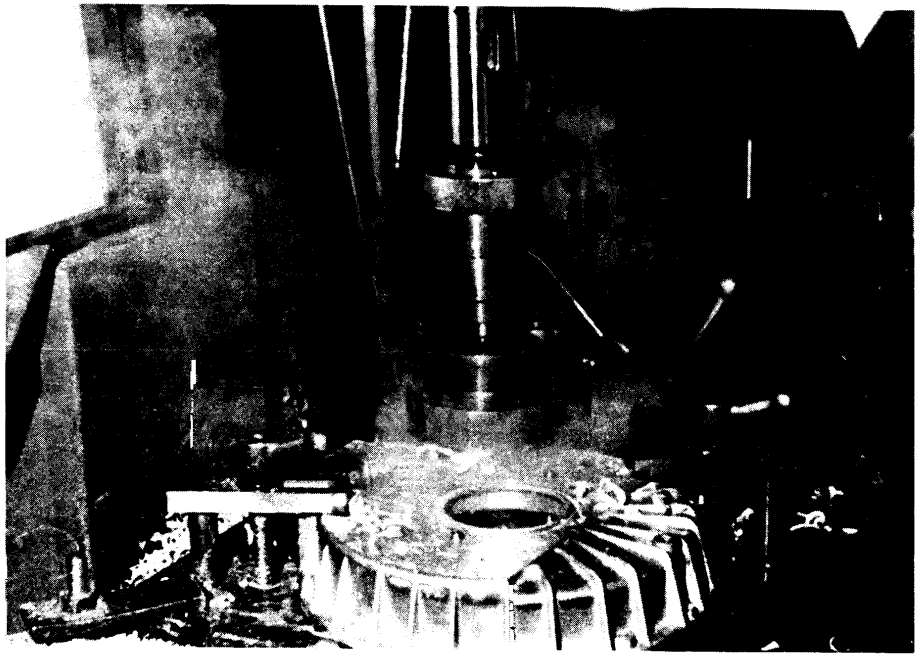


Fig. 6 : Soluble oil coolant mist - Boring Operation

Fig. 7 : Soluble oil mist grinding

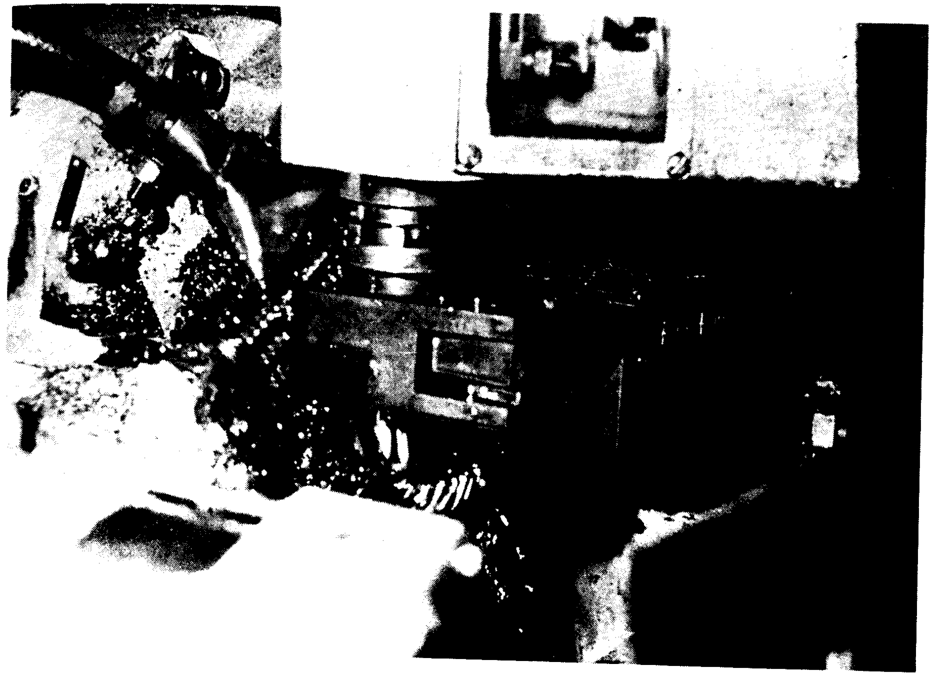


Fig. 8 : Oil mist from oil applied to a hobbing machine via a 'fish-tail' oil mist 67 mg/m^3

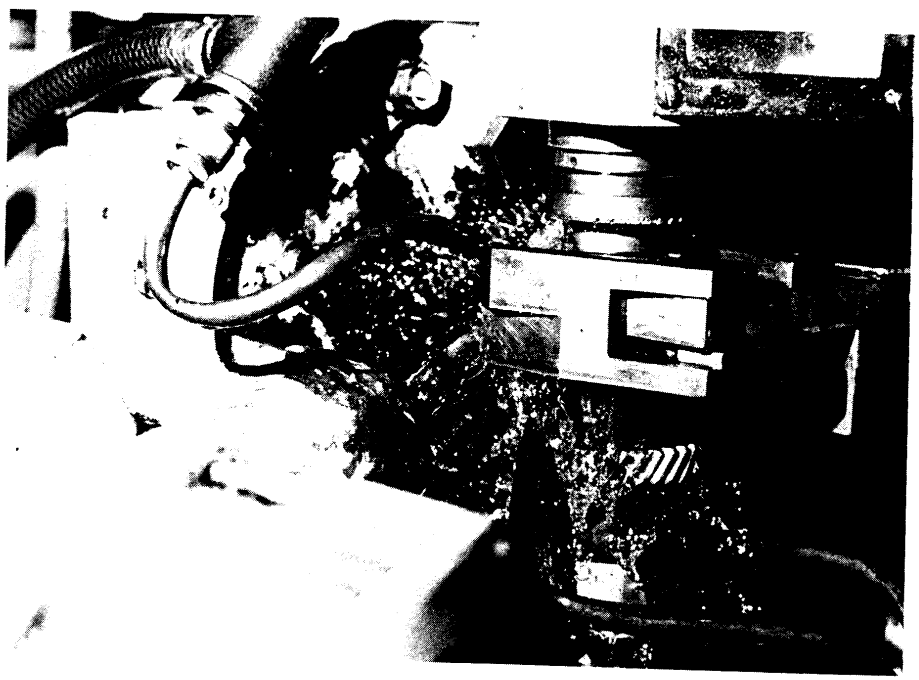


Fig. 9 : Oil applied by 4 pipes to the same machine reduced oil mist to 0.4 mg/m^3

When concentrations reach 1 part in 10 or 20 parts of water, irritation could well be noticed.

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Acknowledgements

The work of colleagues in the motor vehicle industry and the petroleum industry has been referred to in the text of these notes. Their contribution is gratefully acknowledged.

The diagram illustrating the use of a dust lamp is taken from a British Occupational Hygiene Society Publication - Technical Guide No. 7. The copyright for the diagram rests with the Society and permissions to use is acknowledged.

CONTROL OF POTENTIAL HEALTH HAZARDS OF FORMULATION PRACTICE

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1. Introduction

In recent years many sections of industry have come under increasing pressure to assess and minimise the potential health hazards associated with manufacturing processes and the resulting finished products. This has been particularly true of those industries concerned with the supply and use of cutting fluids and has occurred against a background of continuously changing market conditions, and incessant demands for improved product performance and cost effectiveness.

The cutting fluids sector differs substantially from the remainder of the lubricant industry. Specifications and industry standards for products are rare and for actual product performance virtually non-existent. Formulation, particularly in areas such as water miscible products, is often considered to be a 'black art' rather than a science, with the result that the compositions of nominally similar products from alternative suppliers can be radically different. This is essentially due to the fact that it is rare, particularly with water miscible fluids, to come across instances of the same product being used for identical operations in the same machine, under identical conditions. As a result, customer requirements and any resulting problems can vary enormously, and this can have a considerable impact on the formulation strategies of potential suppliers.

Increased awareness of potential health hazards amongst user companies and their operatives have also had a major impact on the marketing strategies of cutting oil suppliers. This has resulted in major revisions to new product profiles. Gone is the requirement for formulators to devise a product to effect particular operations at the lowest cost regardless of other parameters. This has very much been replaced, certainly in more responsible suppliers, by the recognition that there is a need to balance product efficacy and cost efficiency against potential toxicity and likely environmental impact.

It is not the intention of this paper to address all the likely health hazards associated with cutting oils and their control. Direct hazards such as flammability, transport risk, or the impact of accidental spillage will not be considered. Instead this paper will concentrate on the potential health hazards related to the use of cutting oils formulated on particular components, together with any additional hazards resulting from the use of these cutting oils in the field, paying particular regard to dermal and inhalation toxicity. The control of these hazards by formulation practice will be discussed, but it is the author's intention only to provide general advice in this context, rather than produce a long list of "safe" formulations. This is essentially to avoid implied criticism of viable alternative formulation strategies, and of course to ensure the confidentiality of in-house formulations. However, it should be stressed that, certainly in the UK, most reputable suppliers will, if requested, provide a considerable degree of formulatory detail to accredited medical advisers of user companies. This would normally occur under the auspices of a suitable secrecy agreement to safeguard the interests of both parties.

2. Formulation Strategies

For the purpose of this paper, it is convenient to define the potential components of cutting oil formulations as those which are known to be hazardous, those likely to offer a potential hazard and those which are considered to be non-hazardous. Initially it is worthwhile to analyse more closely the formulation strategies applicable to products containing components covered by each of these definitions:

2.1 Formulating away from material known to be hazardous

This strategy would on first inspection, appear to be self-explanatory. Certainly it would be expected that chemicals which posed a known hazard, such as certain carcinogens which are recognized as having caused occupational cancer in humans, would have their use restricted by legislation. Such legislation does exist in the cotton industry which specifies that any oil used from mule spinning must be either of animal or vegetable origin or else a mineral oil which has been refined with sulphuric acid to conform to a particular colour and viscosity specifications (1). However, the only regulations likely to restrict the formulator of cutting oils are those contained in the 1974 Health and Safety at Work Act (2) or the 1984 Classification, Packaging and Labelling of Dangerous Substances Regulations (3), together with its subsequent amendment (4).

Fortunately, most responsible companies and their formulators do not require the establishing of controlling legislation on legal precedent to exclude particular additives from their products. Hence the adoption of severely solvent refined or deep hydrotreated mineral oils with their inherently low PCAH contents for use in neat oils, throughout the cutting oil supply industry since the early 1970s. In addition to this many other toxic materials which were once widely used have been excluded, often purely on the basis of proven toxicity of the particular additive to laboratory animals.

However there will always be instances where no consensus regarding the toxicity of a particular additive, either within the cutting oil industry, or the scientific establishment is available, and hence a somewhat different strategy will need to be applied.

2.2 The limitation or gradual elimination of use of materials which are potentially hazardous

This situation is considerably more vague than that outlined above, since the basis of the strategy will depend on the interpretation of the evidence available suggesting that a particular chemical or additive may or may not be hazardous. Usually no unqualified statement of potential hazard will be available from an authoritative body, and opinion based on experiences in the field with products containing the material may vary widely between companies and individuals.

Sodium nitrite is a good example of an additive which falls into this category. It is well known that under the alkaline conditions of most water miscible cutting oils, sodium nitrite can react with amines to form nitrosamines (5), many of which are known carcinogens (6). Particular attention has been paid to N-nitrosodiethanolamine (NDELA) which has been widely detected, particularly in water soluble synthetic fluids (7,8). In 1984 the US Environmental Protection Agency (EPA) issued a regulation (9) prohibiting the use of nitrite in any cutting fluid containing a triethanolamine salt of a tricarboxylic acid complex. This was widely interpreted as a complete ban on the use of nitrite in metal cutting fluids, which was clearly not the case. In 1987 the Health and Safety Executive issued a Guidance Note (10) which stated the <u>opinion</u> that NDELA should be considered a <u>possible</u> human carcinogen, and advocated avoidance of combinations of amine and nitrite. In practice many UK companies offer both nitrite containing and nitrite-free formulations for virtually all operations, and certainly over the last 4-5 years the trend has been very much away from sodium nitrite containing products. Perhaps the only exception is in the machining of spheroidal graphite (SG) cast iron where nitrite is currently the most effective inhibitor in reducing the emission of the highly poisonous gas phosphine.

An even more equivocal situation exists with formaldehyde, the basis of many formaldehyde-release type biocides which has given indications of carcinogenicity in laboratory animals (11), but despite widespread use in industry, no clear evidence of human carcinogenicity has been found in practice, even in quite extensive surveys (12).

A final example of the problems facing the formulator in deciding which materials are potentially hazardous, is the situation concerning the potential carcinogenicity of chlorinated paraffins which are widely used as EP additives in cutting oils. A two-year gavage (force-feeding) study carried out by the US National Toxicology Program (NTP), utilising high doses of chlorinated paraffin dissolved in corn oil concluded that there was clear evidence of carcinogenicity in rats and mice for a twelve carbon, 58% chlorinated material (13). A twenty three carbon, 43% chlorinated hydrocarbon gave evidence of carcinogenicity in male mice but not in rats or female mice! (14). As result of these tests NTP will not at present list the twenty three carbon 43% chlorinated hydrocarbon as a carcinogen, but further studies are planned. The relevance of the study to actual human exposure has not yet been justified.

The above indicate the clear dilemma of the formulator in choosing additives to produce a given product. In addition to any toxicological information available on established materials, there is often the need to weigh the significance of no, or at the most negligible amount of information on alternatives. As a number of workers have pointed out (15) toxicity testing is not cheap and there is no guarantee that the results obtained even in well planned and executed long term tests will provide definitive or even useful information on the potential toxicity of the substance tested. With this in mind another, more radical formulatory strategy is available.

2.3 Formulatinq products onlv on additives which are considered to be non-hazardous

In many ways this must be considered the ideal solution to many of the potential health problems associated with cutting fluids, or for that matter any other formulated product. Indeed with certain fluids, normally associated with low severity cutting operations such a scenario is entirely feasible. For the most part though it must remain a somewhat distant possibility, rather than a practical proposition.

Essentially the difficulty in producing products of this general make-up lies with the scarcity of toxicological information. This occurs not just for the individual additives but for mixtures of different additives, which may prove either toxicologically synergistic or antagonistic, dependent on factors such as relative concentrations and general environment. A typical example of this is the observation that the toxicity of phenolic biocides is influenced by the diluents used with them as well as the concentration of the diluents. Even natural oils, such as olive oil can increase this toxicity (16).

2.4 Summary

In practice, formulators use a mixture of all the three strategies outlined above. The emphasis at present would appear to be on formulating away from known hazards, but with increasing awareness of potential health risks the other strategies discussed may well achieve a higher degree of importance.

3. Potential Health Hazards and their Limitations

The potential health hazards of cutting fluids can be categorised as those inherent hazards resulting from the incorporation of particular components, additives, or combinations of additives in the actual fluid, and those resulting from the changes to the fluid which can occur in actual use. In fundamental terms the former is generally the more significant, since a cutting fluid which is formulated in ignorance of the toxicological characteristics of its components is likely to cause significantly more serious health related problems than a carefully formulated fluid which undergoes problems which are related to the operation in which it is being used.

3.1 Health Hazards which occur with neat oils and their control

The health hazards associated with neat oil formulations can be conveniently subdivided into the effects resulting from exposure to oil mist and the effects of oil on the skin.

3.1.1 Oil Mist

Initially, it is important to differentiate between oil mist, which is the liberation of oil in droplet form into the atmosphere around the machine, and oil fume which results from partial thermal decomposition of the oil in use. The hazardous effects of oil mist are generally considered to result from droplets which are less than 5 microns in diameter, since these can successfully penetrate the respiratory tract (17). The toxicological effect of these droplets is closely related to that of the actual base oil, and that of any additives present but a considerable impact on the overall level of oil mist, and more particularly on average droplet size can be made by the use of anti-mist additives. In certain circumstances the polymers on which anti-mist additives are based have a tendency to shear. Where mist control is important, for instance, where the recommended OEL (Occupational Exposure Limit, based on an 8 hour time weighted average) of 5 mg/m^3 is being approached, extra polymer may need to be added to the oil in use. This is normally achieved by adding the additive in the form of a concentrate.

Oil fume is a more difficult problem to discuss since much depends on the type and additive treatment of the oil, although in general its occurrence can often be related to incorrect cutting oil selection or an inadequate flow of oil to the cutting zone. Hence oil fume can generally be reduced or eliminated by non-formulatory action.

3.1.2 The effect of neat cutting oil on the skin

Without doubt the most significant health hazard resulting from exposure of the skin to neat oils is cancer. Carcinogenic activity in neat oils is normally associated with the presence of polycyclic aromatic hydrocarbons (PCAH), the type and concentration of which are directly related to the method of refining used to generate the mineral oil used (18). It is widely accepted that the only processes which successfully eliminate the carcinogenic potential of mineral oils are severe solvent refining, or deep hydrotreatment (19) and the use of mineral oils other than those generated by these processes in formulations cannot be advocated. There is evidence that some additives used in cutting oils, notably antioxidants, can inhibit the production of tumours by certain of the PCAHs found in mineral oils (20). Unfortunately, as yet there is no evidence that the carcinogenic properties of all PCAHs can be eliminated entirely so the complete elimination of all carcinogenic potential from mineral oils is not yet possible.

In addition to the potential carcinogenicity of mineral virgin oil problems can also occur with used oils, since it has been established that during use the PCAH content of oils subjected to high temperatures can increase substantially, the extent being dependent on the type of application for which the oil is used (21). With cutting oils, based on highly refined mineral oils outlined above, increases in the PCAH content are normally low depending on the severity of the cutting operation. However, with automotive engine oils the levels of PCAH can increase by as much as 100 times during use, and in previous years these engine oils were simply re-refined; the resulting re-refined oil often finding use, alone or compounded, as a neat cutting oil due to its relatively low cost. Instances of this practice are now much reduced, but certainly it has not been entirely eliminated.

Apart from carcinogenicity the main health hazards posed by neat cutting oils are dermatitis, which is defined as inflammation of the skin resulting from some external cause, and absorption of toxic substances from the oil through the skin layer. It has been said (17) that neat oils rarely cause dermatitis, and there may well be some truth in this when applied only to uncompounded mineral oils produced by the refining processes outlined above. Nevertheless contact with the skin over an extended period even with these highly refined oils has been widely reported (22) as causing dermal irritation due to their defatting action. Lower petroleum fractions, ie., those with boiling points lower than 300°C such as kerosene or gas oils, tend to exacerbate this problem and should be avoided where continuous skin contact is likely. However, for most cutting operations where neat oils are used, additive treated oils are the rule rather than the exception, uncompounded mineral oils having in the main been replaced by water based cutting fluids.

The use in neat oils of additives which are known to be toxic, or are primary skin irritants at the concentrations used is now rare. However, instances have occurred where additives have been found to be contact sensitisers or allergens. Examples are certain epoxy compounds (23) which are used as stabilisers to prevent the breakdown of chlorinated EP additives, and certain olefins (24) used in honing oils. Fortunately, the incidence of dermatitis caused solely by the presence of additives in neat oils is relatively low, a much greater incidence exists where the neat oil has been affected by operational use.

A number of factors can combine to increase the incidence of skin problems during actual use. The most common is abrasion or breakage of the skin caused by swarf, sharp projections, etc. which leaves the skin more vulnerable to attack even by materials which would normally have difficulty penetrating the surface layer. In addition, unless the oil is formulated to have good filterability, very fine particles of swarf or debris, generated during an operation, may cause irritation by entering the pores or hair follicles, which are very vulnerable to this type of attack. This is particularly true when water is present in the oil, since this water peptises metallic swarf, resulting in both an increased incidence, and a higher degree of skin irritation. This water may be from contamination of the oil by water based cutting fluids, which may be preventable, or by other means such as condensation which may not. In this latter case care should be taken to ensure the neat oil used has suitable demulsifying characteristics to allow this water to be separated off. The presence of water can also have a deleterious effect on additives which may break down to give by-products which are irritating. Perhaps the best known example of this type is the breakdown of chlorinated paraffins in the presence of water resulting in the generation of small amounts of mineral acid, which is a primary irritant. Excessive heat will also achieve this breakdown and as a result where chlorinated paraffins are used inhibitors to prevent breakdown may be needed, but care must be taken to choose the correct additive, since some, as indicated above, may cause sensitization.

The machining of certain metals can also lead to dermatitis which may be exacerbated by utilising an incorrect type of level of additive package, leading to high levels of metal salts being suspended in the oil being used. Examples include nickel and titanium, although instances of dermatitis caused by zinc contamination resulting from use of a galvanised tank to store the oil, a condition common with water based fluids, have been recorded. In instances such as these the formulator would almost certainly seek the assistance of an independent dermatologists, to ensure the correct choice and concentration of additives are made to prevent dermatitis whilst retaining acceptable machining performance.

4. Health hazards which occur with water miscible fluids and their control

Incidence of cancer caused by emulsifiable oils is extremely rare and by water based synthetic fluids, virtually unknown. As with neat oils, the health hazards of diluted water miscible fluids normally occur as a result of direct contact with the skin or with the airborne mist. Hazards also exist in the storage and dispensing of the neat concentrate, but these are not considered within the scope of this paper.

Perhaps the main health hazard associated with water miscible fluids, whatever the type, results from too high a level of pH in the aqueous dilution. Since normal skin is slightly acidic (pH 6.8) the best pH for a diluted fluid would be close to this level, ie., neutral. Unfortunately, in order to provide good corrosion protection, particularly on ferrous metals and bacterial stability, considerably higher pHs are necessary. In practice it has been found that fluids formulated to give an operating pH in the diluted form of between 8.5 and

9.5 are the most satisfactory. Higher pHs tend to cause excessive defatting of the skin over even moderate periods of exposure, leaving it open to further attack, and mists of these high pH coolants can cause severe nose and throat irritations. Both conditions can be considerably worsened by the presence of other additives dependent on the fluid type.

4.1 Emulsifiable Oils: Problems associated with cutting oil emulsions and their control

In many ways it was the lack of inherent health hazards with water-based emulsions which spurred the dramatic increased in their use during the 1970s. When based on highly refined mineral oils or synthetic hydrocarbons they contain few additives with the exception of sodium nitrite (discussed previously) and certain biocides, which result in or show any significant levels of toxicity. The most prevalent problem associated with their use is contact dermatitis due to their detergent and defatting action on the skin, exacerbated in this case by certain of the emulsifiers which may be present in the product. Careful choice of additives, allied to strict control of emulsion pH can virtually eliminate incidences of dermatitis in practice, but choice of biocide is perhaps the most crucial factor in preventing major problems in this context. This is essentially due to the fact that many biocides in the neat form are highly toxic, and their use levels in products must be strictly limited if incidences of contact dermatitis are to be prevented (25). Unfortunately in practice, events can often conspire to adversely affect the most carefully formulated products, and a build up in concentration of the emulsion may increase incidences of both skin defatting and contact dermatitis.

Other health problems observed in practice include dermatitis resulting from a build up of salts from the metal being machined or storage tanks, usually nickel or zinc respectively, and problems associated with bacterial spoilage. The best known of the latter is the smell of hydrogen sulphide (often referred to as "Monday Morning Stink") caused by anaerobic sulphate reducing bacteria. However, whilst this is certainly unpleasant it is unlikely to cause serious problems in practice, and can be eliminated by appropriate bacterial control. This can be effected by using a suitable biocide in the concentrate, or perhaps by changing to "biostable" fluid since these can be excellent in preventing infections by sulphate reducing bacteria. Great concern has been expressed regarding the potential health hazards which might result from the inhalation of aerosol mists or skin contact with emulsions contaminated with pathogenic bacteria, which are sometimes detected in certain emulsions. As yet the writer is unaware of any problems which can be directly attributed to this source, although some workers in this field suggest evidence does exist (26).

4.2 Water Soluble Synthetic Fluids: Problems associated with true or extremely fine colloidal solutions and their control

Many of the health hazards associated with water soluble synthetic fluid solutions, such as skin defatting, are common to those already discussed under emulsifiable oils. However, there are a number of important differences in formulation or use which can cause some particular additional problems Firstly, synthetic fluids normally contain high level of alkanolamines to give good corrosion characteristics and buffering capacity at low dilutions. As a result they may still form nitrosamines, including NDELA, even though the products do not contain sodium nitrite (27), although the levels are usually very low. Secondly, since synthetic fluid solutions are normally used for grinding operations, the level of mist inhaled during use may be relatively high. Therefore, care must be taken to ensure that any components incorporated do not present a hazard if inhaled in this context. Health problems have been widely reported in this context, particularly with the alkanolamine soaps of low molecular weight monocarboxylic acids, such as isononanoic acid, which have given numerous instances of sore throats, and some associated breathing difficulties, and should therefore not be considered suitable for use. Finally, synthetic fluid solutions are often used to machine hard metal, which is normally based on tungsten carbide particles in a cobalt matrix. Many additives, such as alkanolamines, increase the rate of dilution of the cobalt which, when solubilised, has caused numerous cases of allergic reaction (28). Elimination of these solubilisation accelerators can severely limit the uptake of cobalt into solution significantly reducing its potential to cause dermatitis.

5. Concluding Remarks

It is now over a century since the practical value of using liquids to aid metal cutting was proven. Great strides have been made in product technology in that time, but only in the last few decades have these advances in product technology been matched by improvements in the reduction of potential health hazards associated with cutting fluids. Today, potential health hazards are in many ways the major factor influencing formulators in their continuous search for new and improved products. The aim of this paper has been to examine some of the strategies available to the formulator, whilst at the same time indicating some of the constraints which can limit their effectiveness. The intention has been to emphasis that although the contribution of the formulator is significant, it forms only a small part of a complex and rapidly growing area of interest in which progress is highly dependent on the work of other specialists. It is by co-operating with these specialists, be they industrial hygienists, toxicologists, dermatologists or others that real reductions in the health hazards associated with cutting fluids will be made.

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Questions

Mr.M.Ganier France I would like to know if you have specifications to control the level of refining of base oils in your company please? Specifications or measurement or control to know if the base oils are good for formulating cutting oils.

Mr.P.J.Ruane Like most companies in this field we have internal specifications that we utilise. Obviously this is an area where there is considerable general interest, but I think it may well be that different companies have different attitudes to this particular situation. As I said we certainly have our own in house specifications, but they tend not to be based on any particular official specifications. I think that this subject is possibly something we could talk about outside the conference.

Mr.H.Krebs Henkel Germany You pointed out that an American study showed chlorinated paraffin could be a potentially hazardous material. In Germany there is a big movement against chlorinated paraffin, not due to the application but due to the handling of the waste oil. Does this cause concern in the UK yet?

Mr.Ruane As you say the movement in Germany is really due to legislation controlling waste. In the UK as far as I am aware there is as yet no real movement to introduce legislation in this area. Whether it is adopted as part of an EEC directive in the future is, of course always open to question. I think to some extent the situation in the UK is somewhat different to that in Germany. In Germany there was a tax advantage to reclaiming used oil. In the UK that situation was never the case and the industry was never quite as well established as it was in Germany. Also in the U.K. we don't have a separate Green Party, or to be more precise, we don't have a Green Party which has an effect on the political power base in the UK, so therefore I don't think we are quite as concerned with environmental legislation as you are in Germany.

Mr.C.Packham Reinol-Janet(UK) Mr. Ruane felt that pH was the main problem with soluble oils. I would tend to agree with Richard Rycroft in his comment that emulsifiers are the main problem. A pH of eight and half to nine and half would only cause skin problems if the duration of the contact was excessive and in that context the emulsifiers would almost certainly be a greater enemy to the skin. In fact there was work done last year Shiga University in Japan on the treatment of people suffering from atopic dermatitis using alkaline soaps with an alkalinity of around ten to eleven and these actually produced a substantial improvement in short term contact with the skin. There is a lot more work to be done on this yet but I would be very doubtful whether eight and a half to nine and a half in the short contact between the oil and the skin that should be occurring with good practice would actually cause problems.

Mr.Ruane Well actually Dr. Rycroft spoke about this yesterday, its a pity he's not here and we could argue this point a bit more fully his comment was that he thought the problem was related to emulsifiers. However a little later he said he thought that water soluble synthetic fluids were in actual fact even more likely to cause dermatitis than emulsifiable oils and of course water soluble synthetics don't normally contain any emulsifiers at all. I was perhaps being a little controversial in saying that it was just pH. Obviously there are quite a number of factors that are likely to come into play. The types and percentages of emulsifiers and of other additives such as biocides which are likely to be incorporated are going to have an important effect. However I think in the main, something that everyone can control in their soluble oils, if they control nothing else, is the pH and I think given if you like a general environment pH in all products maintained in the range mentioned, you would generally see some fairly substantial improvements in health and safety related to skin.

Mr.R.Weaver de la Pena Oils Can I ask Mr. Lee what is your opinion on coolant mist which is produced on purpose by commercially available spray mist devices.

Mr.G.Lee In my experience they are a cause of considerable difficulty, I assume you did mean coolant mists not lubricating mists?

Mr.Weaver Yes on a milling machine for instance.

Mr.Lee Well my experiences have been that they are difficult to control. I can only say in my own industry, when we tried them they proved extremely difficult to control and if you want to control them you are really forced to use local exhaust ventilation. Local exhaust ventilation requires a lot of capital and also requires a lot of revenue to run it.

Mr.Weaver So do you try to prevent their use in the first place?

Mr.Lee Yes, we try to avoid using mist coolant systems. We look upon them with a jaundiced eye.

Dr.P.C.Elmes Cardiff To Mr. Lee. I was interested to hear you say that you thought the 5 milligram per cubic metre limit was too high and I was going to reinforce that by saying that you would have to keep a very much lower limit than that to stop people coming sensitised and developing the occupational asthmas that Dr Burge was talking about yesterday. Once they are sensitized of course you may not be able to expose them to even one milligram or lower. The people who are missing from this conference are the people who make the machines and I was wondering how much cooperation your group (who are obviously buying in new machines every now and again) get from the machine tool manufacturers in producing a machine that has a lubricating system that does not produce mists.

Mr.Lee Our influence is varied. We have certainly endeavoured to influence the Machine Tool Industry Research Association via a number of seminars by revealing our findings, and I think its true to say that some manufacturers do supply machine tools with very much better designed cooling systems. Better cooling systems in that much larger pumps are supplied . Of course, we still get machines of traditional design with inadequately powered pumps so that the volume of coolants you can actually put on to the cutting point is not sufficient. However, I think I have to say a word in deference to the machine tool designer. We often buy the machine tool to cut at one speed and then we double the speed and double the feed to get more production out of it, so we are sometimes our own worse enemy.

Dr.Elmes I was going to follow that up, I have noticed going round factories that the speed of machining and therefore the requirement for coolant is increasing and this means that you are really going to have to flood the cutting tool will this in fact helpful because it forces the machine maker to enclose and prevent the production of mists?

Mr.Lee Yes I think it is. I can certainly recall from my own experience machines where that has actually been done, but I can equally recall machines on soluble oils conventional machines like Ryder vertical lathes which are fairly ubiquitious in my industry for machining fly wheels and brake drums. They use emulsified oils, or other water based coolants. Simple actions like reaming-out the jet points to remove the precipitated fat and accumulated dirt can double the coolant flow and can dramatically change the situation. Workers exposure to coolant aerosols can be reduced to none or virtually none. There is also a great tendency to flatten the end of the coolant pipe to increase the pressure in the belief that this will some how magically improve the cooling. What it will do is to reduce the volume. It is volume of coolant that you require to remove the very large quantity of heat present.

Mr.E.C.Hill Cardiff Could I direct questions to both speakers first of all to Pat Ruane. If we look at the toiletry industry there is a very very well regulated list of preservatives and biocides which are permitted at very well regulated concentrations. Most of these things chemicals also appear as industrial biocides for cutting fluids. Does anybody, when they are formulating cutting fluids, ever look at the toiletries list of preservatives and biocides and at the concentrations which are permitted there? If you are going to put hand lotion on your skin its very much like putting cutting fluid on your skin. Is the same sort of regulatory information or even the same sort of knowledge available to the metal working fluid formulators? If I could add my question to Mr.Lee, is there any sense in looking at perhaps glycol measurements as an indication of total aerosol from metal working fluids. It strikes me that nitrite is the wrong thing to look at at the moment.

Mr.Ruane Regarding the cosmetics industry and the biocides they use I can only speak for my own company in that we follow the publications in this particular area quite closely particularly with regard to topics like contact sensitization for instance. Generally you are quite correct in that the concentrations they are using are substantially greater than those which would occur in the finished emulsions of products where we incorporate biocides. Having said that, you always potentially have a worst possibility situation in practice, whereby through bad maintenance or indiscriminate additions you can have emulsions in which there are substantially greater concentrations of biocide than you would expect. So the cosmetic industries information on upper limits and their effect on contact sensitization is obviously of importance. I don't honestly think I can speak for the oil industry in general on this subject and it would be hard to know the general attitude.

Mr.Hill But you'd look at these lists.

Mr.Ruane Oh yes. In fact I think one of the references I give in my paper is to chloracetamide which is of course now quite widely accepted in the cosmetics industry to be a contact sensitizer.

Mr.Lee Yes I think you are probably quite right Glycol might have been a parameter to have measured, particularly in view of the fact that we seem to be going away from nitrite based materials. I was simply trying to list the limited amount of work that had been done on trying to measure it at all. I can only report the two techniques that have been developed so far. The other thing I think you have got to remember that in the user industry we don't always have the advantages of a university research department behind us and we often have somewhat primitive techniques of measurement.

Mr.H.G.Cattell Rocol Ltd. Highlighting the role of the formulator of cutting fluids, one thing I think formulators of cutting fluids do is to formulate particularly water based ones to be used in a specific dilution range. One thing which I suppose frustrates me is to find complaints coming back when fluids have not been correctly diluted, I would like to hear Pat's comments on dilution control.

Mr.Ruane Yes to some extent we had a go at this yesterday. Regarding dilutions I think I've reached the stage now where I almost expect recommendations to be disregarded and as soon as we get a problem in this context it's immediately the first thing I look for. It's amazing that you find companies who are prepared to spend millions of pounds on new machinery they spend a fortune training the operatives in computer programming so that they can actually run the machines, they invest vast sums in the development of new components to make on these particular machines and yet the very last thing they do is maintain the actual strength of the coolant in the sump. It passes all understanding to some extent but I'm afraid its just one of these things that I have now come to accept as a fact of life, I've even had people stand up in front of me and say this coolant has never been above a particular strength which is usually within the range recommended and you can pull a sample out of the machine stick it on a refractometer and show it to be three times that concentration.

Mr.Lee May I just add a comment supporting that. In fact I didn't know that the gentleman here had visited my factory. He's obviously been in when I wasn't there. It is certainly true that we have found our measurements correlate quite well with complaints of upper respiratory tract irritance especially on grinding machines. The coolant supplier tells us that a product should be used at (say) 1:50 concentration in water. No problems of irritancy are encountered. Allow the concentration to increase to 1:5 or 1:10 and of course you encounter problems. The concentrations of irritant substances in the coolant are increased. I support the comment.

Mr.Ruane Having said that I think it fair to say, with my salesman's hat on, that I much prefer customers to use over concentrated solution than under concentrated!

Mr.P.Oates Castrol Just two points, one to my colleague Pat Ruane. I think during your talk you made the comment that by solvent refining or hydro-treating it was impossible to remove all the polycyclics from a mineral oil. Now that's not quite true because by very strong oleum treatment of an oil or very deep hydrogenation one can remove all the aromatics and its called medicinal white oil. Just a point of correction. The one to Ted Hill with regard to looking at the biocides used by the cosmetic industry. Yes we do we look at the publication by The Food and Drug Administration which lists the biocides which are registered with the FDA. The EPA drug administration registers the use of biocides in cosmetics and medicines for over the counter use. They list the biocides, their concentration and the number of times they are used and of course there is quite a difference with cosmetic. Some are produced under aseptic conditions, it goes in a nice package most likely U.V. light rays over it to keep it sterile and the lady who is going to use it puts her nice clean hands in it. Now if you compare to industry where its been contaminated daily by swarf, by the dirt from the machine, by general dirt coming in on the actual component its a different world entirely.

Mr.K.Emery Colt International Mr.Lee, could you advise us what work if any you have done in investigating the performance and efficiency of local capture and filtration of oil mists from the machines.

Mr.Lee A fair amount of work on efficiency of capture has been done because it is quite easy to do. By visualisation as I've tried to show, you can see whether you are capturing the fume or not. By measurement you can confirm that exposures are under control. Work on filtration effectiveness has been somewhat limited. In the interest of energy conservation the tendency is to return filtered air back to the workplace rather than to simply extract it from the building. A rule of thumb criterion is that the concentration of a contaminant ought not to exceed one tenth of the Occupational Exposure Limit (where there is one). I have to confess that I have very little information about the performance and efficiency of differing filtration systems.

Mr.K.Gardiner, Institute Of Occupational Health. Mr.Ruane. how much cooperation is there between the oil manufacturers and the producers of the machines with regard to formulation? I'm thinking in particularly that prevention is better than control.

Mr.Ruane In my own view not nearly enough. It would be nice to have a situation where we could discuss the design of a machine with its manufacturer, suggest any improvements or changes which would maximise the coolant life and see any results on the final machine. In practice a machine is designed to meet a need and when the design is finalised the manufacturers know what is required of the coolant or lubricant and therefore they can tell us what features need to be designed into the oils. There is a certain amount of cooperation but how relevant this is in the final reckoning to the actual machine that is produced is open to some question, I think what we hope to do is influence machine tool manufacturers to adopt a more sensible approach particularly regard to water based coolants, I was encouraged by what Mr. Lee said regarding the fact that some machines are coming in now that are rather better. I think that perhaps to some extent indicates there is some success, whether we as suppliers of cutting oils who claim to have some small part of that I don't honestly know. I would suspect though, that as in all things, it is the buyer who has the greatest impact.

Mr.Lee Could I just add that some of the better machines, the gentleman at the back there will be very pleased to know come from his country from Germany.

Dr.S.D.Robertson Shell Research I agree with Mr.Ruane about the importance of pH not necessarily just from a purely dermatological point of view. I certainly agree that pHs are an important parameter that should be measured on a routine basis in the plant, the trouble is that there can be some debate as to what in fact is the correct pH. Some people advocate test strips, some prefer hand held glass electrode systems, I wonder in fact what your own view on the preferred method of pH measurement was.

Mr.Ruane I'm afraid I'm firmly in the camp of the instrument as opposed to test strips which I'm not a great fan of to tell you the truth. We have in the last few years seen the development of numerous small or even pocket size pH meters. My own company has tested quite, a few and a lot of them, its fair to say, are rubbish in that the slightest thing will blind the electrode. However there are a few that are quite satisfactory with emulsions and excellent with synthetics. The emulsions that are very badly contaminated with tramp oil are the major problem, as are emulsions that are in use at very high strengths, usually because they blind the electrode very quickly. However I would prefer a decent quality pocket pH metre everytime over test strips.

CONTROLLING MICROBIOLOGICAL CONTAMINATION OF CUTTING FLUIDS

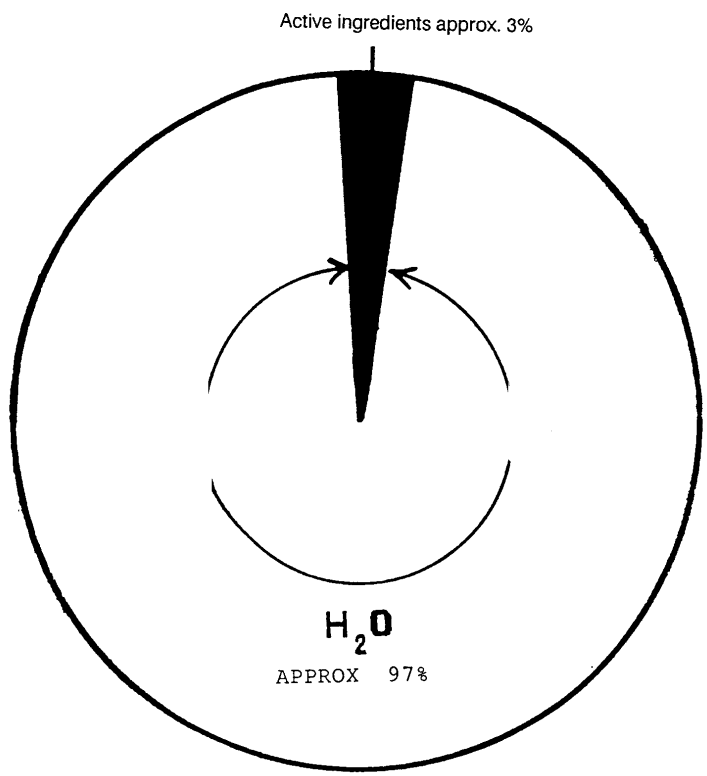
Ray Weaver - Marketing Manager de la Pena Oil Ltd

What contamination are we talking about?

The cutting fluids, a.k.a. coolant, slurry, suds, white water, which are the subject of this paper are, in concentrate form, well protected against microbiological contamination. They contain either relatively high biocide concentrations prior to dilution for use, or insufficient of the water required to sustain the growth of organisms.

Systems operating in theoretically water-free conditions, running for instance on neat oil for broaching or gear shaping, do in fact suffer occasionally from the accidental ingression of water (leaks, condensation etc,) which can eventually form a water bottom beneath the oil. Bacterial and other types of growth in this water can then cause a great amount of damage by corrosion and blocking of filters.

Our concern here, however, is with cutting fluids which are mixed on purpose with water for use as coolants in turning, milling, drilling and other metalworking operations.



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Nowadays, an in-use cutting fluid may consist, typically of 97% water and just 3% active ingredients. These fluids include oil-based emulsions (soluble oils) and semi-synthetics, and oil-free synthetics.

The micro-environment found in the modern machine tool sump can, if uncontrolled, offer an ideal breeding ground for contaminating organisms:-

1. Water
2. Nourishment C,H,P,S,N,
3. 0_2 from the air or chemical sources
4. Comfortable temperature range (10-35^{o}C)

Lack of control by either coolant supplier or end-user will, almost certainly, lead to the troublesome growth of the following types of contamination:

* Aerobic bacteria, thriving in the presence of atmospheric oxygen, and characterised eventually by a rapid drop in the pH of the cutting fluid.
* Anaerobic bacteria, which can multiply in the absence of atmospheric oxygen, say beneath a layer of tramp oil, by splitting chemical sources to obtain oxygen. You will sometimes notice foul-smelling, toxic H_2S around machines with sulphate-reducing anaerobes in them. This is the "Monday morning smell" of rotten eggs.
* And finally, yeasts and fungi.

Of these four classes, it is the fungal growths which are currently held to present the most severe problems to the cutting fluid formulator.

Contamination Control Recommendations

Keep your cutting fluid in undiluted, and therefore protected form, until it is required to be mixed with water for use. Take steps to avoid accidental entry of water into drums or storage tanks. Install drain taps at the lowest point of bulk storage tanks to allow eventual water bottoms to be drawn off from beneath your concentrate. Avoid storing pre-mixed quantities of cutting fluid, unless you can guarantee the regular cleaning of the storage contained. Otherwise, especially if you use cheap and cheerful coolant, you will have heavy infection even before the coolant reaches the machine tool.

Advice like this is typical of the ongoing support required by most end-users, and the benefits of a formal policy of good housekeeping cannot be over stressed.

What are the consequences of this microbiological contamination?

Why spend two days talking about microbiological contamination? After all, it sounds to the disinterested like something that should be just delegated to the lab, or the Health & Safety Officer.

This is, in fact, a big mistake. (The delegation, not the two days.)

Table 1. Some functions of cutting fluids

Cool
Lubricate
Protect machine and components
Prevent smoking
Protect tools
Sweep away chips
Accept bacteria and tramp oil
Be compatible with men, materials and machines
Improve surface finish

Bearing in mind the functions of the constituents of modern cutting fluids, and knowing that bacteria and other things can under adverse conditions feed on these same additives, it does not take much imagination to understand the disastrous consequences of additive breakdown. These consequences affect factory departments far removed from the machine tool:

Table 2 Bacterial Effects on Coolant

Additives depleted by bacteria etc	**Result**	**Affected Depts.**
Corrosion preventatives	Slideway	Maintenance/Production
	Leadscrew rust	Maintenance/Production
	Gearbox rust	Maintenance/Production
	Component rust	Inspection/Production/Sales
Antifoam	Foaming	Maintenance
Extreme pressure (EP)	Poor tool life	Production/Purchasing
	Bad surface finish	Inspection/Production/Sales
Biocide	Bad smells	Health & Safety
	Blocked filters	Maintenance
	Contaminated aerosols	Health & Safety

Cutting fluid which has "gone off" unites many factory departments in an endless round of problems and complaints. How strange then, than most of them could probably not even name the offending fluid or its supplier.

The consequences of microbiological contamination are therefore to be found at all levels in the organisation: they affect directors' budgets, accountants' balance sheets, Q.C. inspectors' statistics, and the operators' peace of mind - for who would willingly put his or her hands into something smelling as "off" as only "off" coolant can smell? And to cap it all, the contamination hits us all, ultimately, in the pocket.

So the liquid written off as slurry or suds has a very significant organisational effect as soon as it fails to do any one of the many tasks it is supposed to (see Table 1). This effect can be translated easily into financial terms.

What are the financial effects of microbiological contamination?

The names of the offending strains of bacteria and fungi may be as unfamiliar to you as they are to me, but more familiar is the name of your Director responsible for finance. Let me give you some brief examples of the knock-on effects of contamination:

a. Fungal growths block the coolant filters on a Yamazaki or other CNC machining centre. Machine shutdown for 3 hours for complete cleandown, including removal of swarf conveyor.

   Cost:
   3 Machine hours at £60/hour; 3 operator hours at £10/hour.
   3 labourer hours at £6/hour. Disposal of 200 litres of emulsion at £0.02/litre.
   Total Cost £232.

b. Even more extreme, "off" coolant in a rolling mill central system. Remove and replace 9,000 litres of rancid emulsion. Approx 2 days work.
   Total cost £650.

Contamination causes downtime and enforced idleness, which is an economic abomination. The total cost of "off" coolant is many times the cost of the replacement coolant: to re-fill the Yamazaki might only cost £15, even using state-of-the-art coolant.

So, to what extent can control of contamination be demanded?

Is 100% control of microbiological contamination feasible?

The answer must be a guarded 'Yes'. But in an ideal world, which does not yet exist. As from tomorrow, cutting fluid manufacturers could build into their water-mix fluids biocides and fungicides in such quantity and of such a nature as to destroy effectively the microbiological flora and fauna which cause the problems.

We could give you certain phenolic compounds, or excessively high levels of borate ester, or questionably high levels of formaldehyde, for instance. End of contamination problem? Yes. End of problems altogether? No.

This proposed use of superpowerful killer chemicals fails to take into account the fact that men still interreact with machines and materials to make up the 3M's of production engineering. If we supply the sterile cutting fluid capable of permanently killing all bacteria life, what of the operator forced to work with the fluid?

Even the most sophisticated machining systems, which run essentially without operator intervention, are not really candidates for the use of superhard fluids. The system will still occasionally need to be cleaned, repaired or modified by human hands. The components will need to be handled for inspection, packing or assembly. Would you then want to be the packer who packed the component machined in the "hands off" cutting fluid?

Similar reservations must be voiced about post-treatment with biocides and fungicides. Look at the following calculation:

Machine Sump Capacity	Actual coolant content	Actual biocide	Recom. biocide level	Addition needed
400 litres Or was it gallons?	Nearly full	What?	1200 ppm	1200 ppm minus present level x approx 40 litres

The uncertainity in the calculation is a powerful argument for not giving biocide to end-users, as human nature often encourages an extra dose for good measure.

So, 100% control of microbiological contamination in the context of the forseeable future is unlikely, due to the unpleasant side effects for operators, and consequent disposal problems, which can be brought about by powerful or questionable biocides.

Can we do without control altogether instead?

Again, the answer is a guarded 'Yes'. We can supply unprotected fluids which contain none of the additives which operators might react to. The consequence, within just a few days, would be a foul-smelling workplace with the problems related to high levels of bacterial. It would be necessary to empty, disinfect and refill the machine tools very regularly and the economic viability of this "control-free" approach is non-existent.

A compromise is called for.

Is there a viable control compromise?

It must lie somewhere between the extremes of 100% control and 0% control, both of which extremes are equally problematic.

Our contention, based on experience, is that there can be a cost-effective level of control of microbiological contamination, which takes into account

* men
* machines
* materials
* disposal

Our proposed solution is a Coolant Management System, based necessarily on a team effort.

The team will consist of
- Quality cutting fluids and related products
- Ongoing supplier support of a non-sales nature
- End-user co-operation

and the intended aim is the achievement of cost-effective long cutting fluid life by close attention to the correct usage of the correct cutting fluid. By life, we mean here the interval between unacceptably high levels of contamination, which result in bad smells or other difficulties.

The contribution of the cutting fluid and related products

A substantial contribution can be made by thoughtfully formulated fluid. Please bear in mind that in general, you get what you pay for, and a 0.70/L product is liable to be quite different to a 2.70/L product, and not just in price.

Perhaps the most important related product is the cleaner/steriliser fluid, which should be used to generate optimum conditions in the sump, prior to putting in fresh coolant.

There are "hands-on" cleaners available, which you mix into the spent fluid and allow to circulate for several hours. These contain emulsifiers and quick-kill biocides. Alternatively, "hands-off" cleaners may necessary to purge obstinate machines of stubborn contamination. The former, softer products entail less lost production time, as work continues while they circulate.

Contamination Control Recommendations

1. Experiment with cleaners designed to foam, as the foam wet and be active on machine parts never touched by coolant (inside castings etc).

2. Fill the machine tool to capacity for cleaning purposes.

3. Do the best possible physical clean to remove swarf, scum, slime and general debris. Vacuum-powered units, like the patented de la Pena Freddy and others, will empty a machine quickly, and Freddy will filter and aerate the coolant on a regular, preventative basis prior to disposal.

Cutting fluids may contain one or more specific biocides or fungicides, at a level of 500-1500 ppm in the working emulsion or solution. These materials can be based on eg., formaldehyde, organo-chlorine compounds, quarternary ammonium salts and phenol. The formulator has to bear in mind the cost, effect and acceptability of the finished product, and disposal problems with phenol, for instance, may far outweigh its efficiency as biocide. More modern (and expensive to make) fluids sometimes contain boron compound to give longer term protection against contamination. In fact, cutting fluids can be broadly split into.

a. traditional fluids protected only by phenol (NOT RECOMMENDED)
b. traditional fluids protected only by non-phenolic biocide
c. more modern fluids, protected longer term by boron products rather than just by biocides.

Does anyone in the audience know which category their coolant is in?

By the way, the difference is one of cost, as well as quality. Item c) can be cheaper to use than a cheap phenolic coolant, because it lasts longer, but the litre price of concentrate will always be higher. Find out the cost of use, not the cost of the concentrate!

At this point, let us mention in passing the feasibility of continual biocide addition as practised now by many U.K. end-users. Products are available, based on relatively quickly and easily biodegradable materials, but post-treatment brings its own problems: what volume am I treating? What is the current level of additive in there? How much do I now have to add? The answers are beyond some people, and others may find that regular treatment makes a cheap coolant longer lived but no longer cheap. So what must the supplier offer, other than just product?

The contribution of ongoing supplier support (of a non-sales nature)

If the dream coolant (buy it, use it and forget it) did exist, it would not take into account what we can call the "people factor". Because it is people who will buy the correct cutting fluid, then store it wrongly, mix it wrongly, and run it at 0.5% or 18%, instead of at 3%. People will also throw their cheese sandwiches into the machine sump, or treat it with the Jeyes Fluid they put on the garden.

To counter the "people effect", the end-user should choose a supplier set up to offer ongoing customer where it is needed: this means in the works. Coolant business may be won in the boardroom or purchasing office, but coolant goes off in the machine. The supplier therefore needs, I would suggest, practically minded service engineers to monitor the in-use condition of the fluid and to educate and train operators and supervisory staff on an ongoing basis.

The final contributor to the system of coolant management is the user.

The contribution of the end-user

Co-operation from the user is vital, because he will determine, day-to-day between the service visits made by the supplier, the effort put into monitoring of coolant storage, mixing and monitoring. The caring factory will appoint a suitably senior person to be specifically responsible for coolant, and demand close co-operation between the supplier and this person.

Regular training before and after the introduction of a new supplier's coolant will ensure maximum awareness in the works not just of what to do, but why.

Can I put just two questions to the audience?

1. How many of you can name the cutting fluid supplier in your works or other establishment?

2. How many of you are aware of already having fluid problems apparently related to the contamination we have discussed here?

Conclusions

To keep microbiological contamination within acceptable bounds, you need to manage your cutting fluids.

* Product as supplied to you in the barrel is not enough by itself. Ideally, it should be introduced into relatively favourable, clean machine conditions, after correct storage and mixing.

* Planned in-use monitoring will ensure maximum resistance to contamination for an extended period. It is unlikely that most companies will have the manpower, knowledge or motivation to allow them to be solely responsible for regular monitoring, interpretation of results and rectifying action without regular visits from the supplier's coolant service personnel.

* Seek out a cutting fluid supplier willing and able to shoulder a large part of the responsibility for fluid life and performance.

This will necessarily involve the supplier in the furnishing of

- cutting fluids
- cleaners/sterilisers
- machine tool cleaning units
- mixing valves
- refractometers
- after sales monitoring, planned and regular
- advice, seminars and education

The message therefore, in the face of a potentially problematic set of circumstances, is a positive one. Excellent control of microbiological contamination is possible, given that it is more than just a question of what you buy in your barrel, and how cheaply you got it.

Much work remains to be done to persuade end-users that cutting fluids are engineering products, with a considerable negative impact on budgets when they go wrong, both in replacement terms and knock-on costs of downtime.

This brief talk will, I hope, motivate you to discuss with the cutting fluid industry in advance ways to prevent rather than cure contamination.

If you should go away and address these potential problems before the machines smell, or the operators complain, then these two days will have been extremely profitable for you.

Paul de la Pena Grou

Customer [redacted]
Address [redacted]

Account No.
Machine Name/No.
Coolant type
Coolant condition
Concentration
Detailed Report (if ap
Machine type
Operation
Material
pH
Contaminants
Tramp Oil
Coolant Age
For analysis:
Coolant sample
Other sample
Dipslide type
Dipslide result
Action taken and/or re
Adjust 9
Suggest
Mixing
alterations
dumped in
Next visit due:
Action Head Office:
Report, if needed, for

CUSTOMER COPY

de la Pena Oil Limited

Racecourse Road Pershore Worcestershire WR10 2DD

Paul de la Pena Group

No. C 0665

Engineer [redacted]

Call Date 23/8/1988

COOLANT SERVICE REPORT

Customer [redacted]

Address [redacted]

Contact Mr [redacted]

Position Maint. Mgr.

Scheduled Visit ☑ Visit Frequency 2 ~~weeks~~/months

Coolant trial ☐

Call-out ☐

Special attention to:

Account No.

INTERNAL COPIES TO:

Machine Name/No.	17	16	13	12	1	19
Coolant type	923	901	901	901	901	901
Coolant condition	Good	Good	Good	Good	Good	Poor
Concentration	3%	4%	3%	5%	4%	1%
Detailed Report (if applicable)						
Machine type	Grinder	Mill	Mill	Mill	Lathe	Mill
Operation						
Material						
pH	9.2	9.1	9.1	9.2	9.2	7
Contaminants						Rags
Tramp Oil						Heavy
Coolant Age	>12m	>12m	8m	9m	8m	5m

For analysis:

Coolant sample

Other sample

Dipslide type

Dipslide result

Action taken and/or recommendations:

Mixing valve check 2 % Ref

Adjust 901 to 4% in all machines a.s.a.p. Suggest removal of tramp oil in m/c 19 with FREDDY. Mixing valve to be checked regularly as unauthorised alterations are being made to %. Old rags also being dumped in sump of m/c 19.

Next visit due: end 10/88

For customer: [redacted]

Action Head Office:

Engineer [redacted]

Report, if needed, for customer ☐ or engineer ☐

Questions

Mr.G.Lee Austin Rover Group. Just a comment the reason for using water from the hydrant is it is not metered you don't have to pay for it.

Mr.R.B.Weaver I'd not even thought about that. The bad effect that it had on the coolant is that they were putting water into concentrate at high pressure and producing in fact an inverse emulsion which split very very quickly and it took an awfully long while to work out why they were getting the problems they did get.

Mrs.S.Stimson CEGB You said that you could put the cleaning fluid in and run the machine, yesterday it was stated that this sometimes affected the operator and it was not such a good idea to run a machine for a whole shift with cleaning fluid in, what comments do you have about that?

Mr.Weaver We choose to do it as a company but when you are in control of your own formulations basically you have got to make sure that you are supplying something which is acceptable. One solution we have found raises the pH quite slightly and the main thing that the operator notices is that there is a lot of foam generated which is the complete opposite of what you would normally try to produce in the machine tool, I prefer those hands-on cleaners because very little production time is lost. The other alternative that you have is to go in with the "goggles and gloves" approach and a lot of end users don't like to see that approach on the shop floor. Because literally we would not give or sell products of that type to an end user, we would do that second approach under our own control.

Mr A.Coutts Rohm and Haas. Just a quick question, how do you currently measure the level of biocide as a customer service and which biocides can you actually measure?

Mr.Weaver What we are measuring at the moment is the level of formaldehyde in those products that contain formaldehyde. Our policy has not been one of continual biocide addition, and we have preferred that when coolants are in bad condition they are thrown away and that the customer starts again with a clean machine. If I could just add we find it very difficult as a supplying company to persuade people to run a coolant at four percent plus or minus one, and if customers consistently fail to run the coolant at the correct strength we don't particularly fancy supplying them with biocide which has got to be used at a very very carefully metered level.

Mr.Coutts When you talk about treatment with biocide all you talked about is this curative treatment we have heard a lot about toxicology of biocides in this meeting and surely the methods we should be looking at should be preventative and not curative. Preventative levels of biocide treatment require user level of biocide that is not toxicologically safe and the risks of handling that amount of biocide are necessarily smaller and by measuring the chemical stability of a biocide in a coolant you can come up with some idea of stability in that coolant and come up with a reasonable dosing regime that necessitates a preventative treatment. Using a biocide curatively is using a biocide like a disinfectant and most biocide people that are here, will say that their biocides are not disinfectants but are preservatives and should be used that way.

Mr.Weaver I think it reflects on the type of business we do in the UK, where probably 95% of the volume that we sell in the form of concentrate is destined for use in relatively small individual machines. So we have got a multiplicity of problems when we have got problems, we've not just got four central systems that would be easy to monitor and treat. We have got X machines split amongst Y customers and we have gone completely against post-treatment by the customer.

THE INDUSTRY'S VIEW OF THE HEALTH HAZARDS OF CUTTING FLUIDS

P D Oates - Manager Industrial Technology, Castrol Ltd

Summary

The paper reviews potential health hazards of metalworking fluids. It also covers health aspects of product contamination during use and advises on precautions to avoid adverse health effects.

Introduction

The record of the petroleum industry during the last decade in advising the users of its products in their safe use is one which it is extremely proud and one which it wishes to maintain through the next decade.

Wherever possible the industry has responded rapidly to challenges when the use, abuse or a particular application of one of its products has posed a potential health hazard. The range of products produced varies from volatile light hydrocarbon fractions to highly viscous lubricating oils; from aromatic free, highly refined mineral oil fractions, approved for incidental food contact to black bituminous road and roof coatings.

Mineral oil fractions used in the manufacture of metalworking fluids are:-

Light hydrocarbon fractions - honing and grinding oils;
Light spindle oils - neat and soluble oils;
Medium viscosity lubricating oils - combined lubricant and coolant;

Products from the Petro-chemical industry used in the manufacturing of metalworking fluids include:-

Salts of synthetic carboxylic acids - emulsifiers;
Ethoxylated and propoxylated alcohols, phenols and acids - lime soap dispersants and emulsifiers;
Alcohols, glycols and glycolethers - coupling agents.

To formulate a metalworking fluid the manufacturer takes such products from the petroleum and petro-chemical industry and blends them with other additives. The properties and uses of these components are described in the paper presented at this conference by P J Ruane.

No industry is 100% safe - there is always, always has been and always will be a potential health hazard whether it is in the mining, engineering, food or service industries. It is the responsibility of management to ensure that any potential health hazard is investigated and monitored by those trained to examine such potential incidents - Occupational Hygienists, Safety Officers, Medical Officers and Technologists and if such an incident is considered to represent a genuine hazard to the health of either workers or the general public then action should be taken.

There is a tendency for what may be considered a potential health hazard to become emotive, with the threat of labour disruption leading to a breakdown in production scheduling. However, it is important that potential hazards be investigated by scientific experts and more importantly adequate monitoring of the environment, whether it be atmospheric or aquatic, needs to be conducted so as to quantify the suspect material.

If a potential health hazard is identified there are 3 distinct stages in the "removal" of this hazard:

1. Elimination
2. Substitution
3. Protection

1. Elimination

If a particular product or process which has been identified by experts as posing a potential health hazard can be eliminated then one must establish the motive for the use of either the product or the process in the first place. This is not the normal course of action and management responds by .....

2. Substitution

During the last decade both the petroleum and engineering industries have responded to occurrences potentially hazardous to health by the substitution of one product by another which either dermal or biological testing has shown to be safer. If, however, the challenge cannot be satisfactorily resolved by either elimination or substitution, or the substitution still poses a potential but even very slight hazard then management must respond by ......

3. Protection

This is the normal course of action to be taken by management in the majority of situations after detailed investigation and accurate monitoring of the work place situation has shown a potential health hazard exists. Protection is the most positive influence in minimising any potential health risk whether this be by providing.

Splashguards,
Protective clothing or,
Exhaust ventilation

and undoubtedly attention paid to protection will, in the majority of cases, reduce other potential hazards as well as the specific problem for which protection was considered necessary in the first place.

Now consider the hazards and how the petroleum industry has responded.

Cancer - Polycyclic Aromatics (PCA's)

In the 1968 the publication of SRS 306 by the Medical Research Council (1) identified a relationship between the method of refining petroleum products and their potential carcinogenicity. The Institute of Petroleum (IP) was, during 1967, presented with a proof copy of this report and immediately formed an ad hoc committee to study the potential carcinogenicity of metalworking oils. After careful study and research this ad hoc committee made recommendations to Council who advised their members (2) to reformulate neat metalworking oils with, solvent refined mineral oils, or oils so treated as to severely reduce the PCA content. This was followed by a very positive course of action of information and education. Specific advice was issued by the Institute of Petroleum, the Factory Inspectorate (now the Health and Safety Executive) but more importantly by the suppliers of metalworking fluids.

This ad hoc committee of the Institute of Petroleum became the Advisory Committee on Health and has during the last 20 years been extremely active. One of its tasks was to research the possibility of developing an analytical method which would predict the potential carcinogenicity of metalworking oils; the results of this research were published in 1971 (3).

Secondly, it agreed to a proposed by the University of Birmingham to mount an in depth investigation in to the subject of occupational skin cancer and the Institute agreed to provide financial support.

The main objective of this project was to study in depth the histories of the 253 known cases of scrotal cancer recorded in the Birmingham Cancer Registry since 1950, in order to establish the aetiology of the conditions and to identify important causal factors. The report was published in 1975 by the University of Birmingham under the auspices of the Institute of Petroleum (4).

The last 20 years have seen the reformulation of both neat and water soluble metalworking fluids and these products are now manufactured using highly refined oils. There may be one or two specific applications where the use of less well refined aromatic distillates is needed to satisfy the technical requirements of the particular application, however, the management and workforce will be informed that such products pose a potential hazard and skin contact must be avoided. So although total elimination of mineral oil has not been possible the substitution of an aromatic distillate by a more highly refined fraction has drastically reduced the incidence of scrotal cancer. - **Or has some other factor had a greater influence?**

- Protection and Education! -

Dermatitis

Excessive contact with mineral oil may lead to a number of skin disorders (5). Defatting , oil folliculitis, oil acne, may be caused as a direct result of excessive contact with metalworking fluids. Neat metalworking fluids are more likely to cause oil folliculitis and oil acne than are water based products and such conditions may occur at the site of exposure or contact when exposure is repeated and prolonged.

Allergic skin sensitization has not been demonstrated in animal tests (6) and has not been reported in man from exposure to mineral oil.

Volatile and low viscosity mineral oil fractions will defat the skin unless adequate protection is taken to prevent excessive contact as will over strength emulsions of aqueous based metalworking fluids. Whatever the hazard, the petroleum industry has, by the publication of booklets on the health hazards of petroleum products, Material Safety Data Sheets - Product Information Sheets, service literature or by collaborative advice in the IP Code of Practice on Metalworking Fluids (7) advised management of the potential hazards associated with metalworking fluids and proposed reasonable and safe working practices:

Minimise skin contact;
Worker education and protection;
Machine design;
New Manufacturing procedures;
Choice of the correct type of protective clothing.

Once again the petroleum industry endeavours to alert engineers to possible hazards associated with the products it supplies to that industry by a process of education, first of management, and then of the workforce in the form of personal visits - by Sales Representatives or Technical Advisers. Symposia and conferences and more importantly health and safety information sheets all serve to communicate the necessity of adopting safe working practices.

Oil mist

Oil mist contamination of the working environment is a potential problem particularly associated with the use of neat metalworking oils. This oil mist may be generating as a result of mechanical processes such as grinding or, by fast revolving machinery dispersing oil droplets into the atmosphere or, may be due to inadequate flow of a fluid over a hot surface so producing oil vapour condensing into oil mist.

Substitution of a neat metalworking fluid by a water dilutable product will in the majority of cases completely eliminate the problem of oil mist in the working environment but this is not always technically possible. There are specific operations where a neat metalworking fluid must be used. The petroleum industry has responded to this problem and research has shown that it is possible to reduce the tendency of an oil to mist by the addition of a polymeric material. However, a more significant reduction in the atmospheric oil mist concentration within the factory can be accomplished by the judical choice of splashguards, exhaust ventilation, machine enclosure, provisions of adequate fluid volume at low pressure or the aforementioned total substitution of a neat metalworking fluid by a water dilutable fluid.

Used Oils

Neat metalworking fluids may become contaminated or may undergo degradation. Typical contaminants are: metal swarf, grinding debris, tramp (leak) oils such as hydraulic and lubricants and in water based fluids microbial contamination.

Research conducted by hygienist members of the Institute of Petroleum Advisory Committee on Health (8), showed evidence of a minor increase in the Polycyclic Aromatics (PCA's) content of neat metalworking oils during use but well below a 10 fold increase. Those oils which had been subjected to extended use at high temperatures such as Quenching oils showed a 100 fold increase PCA content. It is reasonable to assume that there may be some increased risk from used neat metalworking oils but it should be noted that the level of PCA's in these oils was well below the level of PCA's present in used oils from other sources eg., gasoline crankcase lubricants.

Pathogenic Bacteria

The majority of metalworking emulsions will after a period of time in use support the growth of moderate numbers of non-pathogenic bacteria. Other papers presented at this conference have dealt with the types of such bacteria.

Regular monitoring of commercial aqueous metalworking coolant, systems has shown only the occasional presence of pathogenic bacteria, perhaps once every 2 years. The choice of the correct aqueous based metalworking fluid properly monitored and controlled by either, the supplier and/or the user will ensure that such systems are maintained in a satisfactory condition. This will minimise any potential hazard, either real or imaginary, to the worker. Advice as to how such fluids are to be maintained can be obtained from the supplier or reference made to the IP Code of Practice on Metalworking Fluids (7).

Legionnaires' Disease

Only one recorded case of Legionnaires' Disease has been reported in the literature (9) which has been directly attributable to the contamination of an aqueous based coolant by Legionella pneumophila - "Pontiac Fever".

Legionella is widespread in natural sources of water including rivers, lakes, ponds and streams and may also be found in soil (10).

Conditions which affect the growth of Legionella include:

1. The presence of sludge, scale, rust, algae and organic particulates which are believed to provide nutrients for growth;
2. Water temperatures in the range of 20-45^{O}C.

Legionella has been identified in air conditioning and industrial cooling systems, humidifiers and hot and cold water services. Although healthy people may develop Legionnaires' Disease, individuals particularly at risk are the infirm.

Research has shown that Legionella cannot grow in aqueous emulsions of metalworking fluids - it is killed by the alkaline conditions and the biocides incorporated in such fluids.

Experience with contamination of aqueous coolant systems in the USA at a General Motors Factory - "Pontiac Fever", showed that aqueous cutting fluid systems which had been improperly maintained using very dilute emulsions of low alkalinity had a potential to support the bacterium just as in aqueous cooling water systems that are not properly maintained.

It is concluded that proper education, allied to monitoring and control of aqueous metalworking coolant systems will effectively prevent the growth of Legionella.

<u>AIDS</u> (Acquired Immune Deficiency Syndrome)

The author has been asked whether it is possible for the virus that causes AIDS to be found in aqueous based metalworking emulsions. Advice has been sought from experts in communicable diseases who have advised that it is very difficult to detect the actual virus in humans - confirmation that a person has been infected by HIV (Human Immunodeficiency Virus) is by the identification of the anti-bodies. Theoretically, in order for the virus that causes AIDS to thrive there must be a protein source. This is absent in a metalworking fluid emulsion.

A further question has been asked of the author, "Is it possible to become infected with the AIDS virus from a soluble oil that has been infected by carrier of the virus?" The questioner was concerned that infected blood from a cut finger of a carrier could be a possible source of the infection that could contaminate an aqueous coolant system. Advice was sought and the author has been assured by eminent virologists that the virus is unlikely to survive in an aqueous based metalworking fluid but this cannot be proved. It is frail virus, and does not survive for long outside the body, particularly in a hostile environment.

Nitrosamines

Water based metalworking fluids containing nitrite and triethanolamine have been marketed by the petroleum industry since the early 1950's. They are used in coolant systems in production engineering processes involving metal cutting or grinding where the function of the nitrite and amine is to minimise corrosion of machine tool and workpiece. The fluids are supplied as concentrates to be diluted with 50-100 times their volume of water before use.

For very many years it has been known that nitrites and secondary amines can react in acidic aqueous solutions to produce a class of compounds known as nitrosamines. Some nitrosamines have been found to be carcinogens when administered to animals in comparatively large doses. In 1975 the IP Advisory Committee on Health was advised that reaction between nitrites and amines could take place, to a lesser extent, in alkaline conditions, such as those prevailing in metalworking fluids. Investigations were therefore, undertaken by member companies of the Institute of Petroleum to ascertain if nitrosamines could be found in these fluids, either before or after use. The specific nitrosamine to be sought was N-nitrosodiethanolamine (NDELA) formed by a reaction between nitrite and diethanolamine. At the same time a literature review on the toxicology of nitrosamines was undertaken and updated as the work progressed.

In 1980 the Institute of Petroleum Advisory Committee on Health advised their member companies (11) and users as to the precautions to be taken to minimise exposure of such fluids until satisfactory replacements for nitrites and amines could be found. This advice has been reinforced by the recent publication by the Health and Safety Executive of Guidance Note EH 49 (12).

There is no conclusive evidence that nitrosamines such as NDELA are human carcinogens. Amine/nitrite grinding fluids have been used extensively since the 1950's and as such, epidemiology studies have been unable to demonstrate any causative association between cancer deaths and exposures to these substances. One study (13) specifically relating to this area involved 219 workers exposed since 1956 and it failed to show any association.

Summary

The petroleum industry is a responsible caring industry whose objective is to produce and market products which are safe when used in accordance with the manufacturers' recommendations for the stated application(s).

The petroleum companies conduct research and investigations in their own laboratories and sponsor collaborative research to investigate common industrial problems either through the Institute of Petroleum or though bodies such as CONCAWE, the oil companies' European organisation for environmental and health protection.

It wishes to be seen as an industry that produces products that function efficiently, are safe to use for the application for which they were intended and which, after use, may be disposed of, without damaging the environment.

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CUTTING FLUIDS- THE HSE VIEWPOINT

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1. Introduction

It is evident, from reports we received from Inspectors, that most users of cutting fluids take a very casual attitude to the cutting fluids in their factories. This is a pity because a more systematic approach would probably pay dividends, not only in terms of reduced health risks and improved working conditions, but also in product quality and reduced costs in the unnecessary replacement of fluids. For example, too weak mixtures of soluble cutting oils may not have the lubrication or corrosion protection qualities required. Fluids which become contaminated may be discarded prematurely.

Recent and proposed changes in legislation affecting the supply and use of substances at work could change these attitudes. The Health & Safety Executive is also planning to issue a Guidance Note on metalworking fluids in late 1988.

2. Changes in legal Requirements

(a) Supply

Manufacturers, suppliers and importers of substances for use at work have had duties since 1975 under Section 6 of the Health & Safety at Work etc Act 1974. These included a requirement to "secure the availability of adequate information" about the risks to health and safety posed by the substance, the results of any testing carried out, and any conditions necessary to ensure it can be used safely. Most suppliers have drawn up "data sheets" to meet this requirement, but for a number of reasons this information has not been getting through to the final users.

One of the important changes to Section 6 made recently under the Consumer Protection Act 1987 is that this information must now be "provided" to the user. This does not mean that it must be "provided" with each batch of fluid. It clearly must be "provided" initially. There is also a requirement to update past customers if it becomes known that the substance(s) pose a serious risk to health, if it is reasonably practicable to do so.

The requirements about the safety of the product and the amount of information to be provided remain largely unchanged. (The risks during storage also have to be considered.) However, many suppliers will be reconsidering their products and data sheets in view of the "Product Liability" parts of the Consumer Protection Act. These are related to "civil" liability and are not enforced by the Health & Safety Executive.

The user of metalworking fluids should now be much better informed of the risks from the products he uses. He must use this information and others available from trade associations, HSE etc, to examine his own working conditions.

(b) Use

At present users of cutting fluids must comply with the general requirements of the Health and Safety at Work etc Act 1974. There are however, proposals for the introduction of specific Regulations affecting the use of substances. The Control of Substances Hazardous to Health (COSHH) Regulations will repeal most of the current piecemeal legislation on substances hazardous to health and replace them with a single systematic approach.

In brief the Regulations will require an initial assessment of the risks involved in the use of a substance, considering all aspects of this use including maintenance, cleaning etc. Adequate means should then be provided in control the hazard. The Regulations make it clear that this control should, where reasonably practicable, be by means other than personal protection. This control must be maintained, and there should be adequate training of employees. In some cases monitoring and health surveillance will be required, the circumstances being made clear in a general Approved Code of Practice and a second Approved Code on Carcinogens. It is interesting to see that non-solvent refined mineral oils are included in the proposed list of carcinogens.

Although the Regulations are still in draft form a number of organisations, including the Institute of Occupational Health, are already running courses on COSHH, in particular on the important initial assessment.

3. **Guidance**

The Health & Safety Executive has, for a number of years, published a number of documents on various separate aspects of the use of cutting fluids. These have included leaflets on the cancer hazards of mineral oils, and guidance notes on dermatitis and nitrosamine formation. However, a Guidance Note has now been drafted drawing together all these aspects. It is likely than this will be subject to consultation soon with interested parties including major users and suppliers, trade unions and trade associations. It should be published in early 1989.

The outline of the guidance note will, not surprisingly, follow the format of this conference covering the composition of the fluids covered, the hazards, controls and training including first-aid. These topics have already been covered in some depth by other speakers, but it may be useful to explain some particular points of interest.

(a) Hazards

The links between the use of neat unrefined mineral oils an skin cancer, and between some water based cutting fluids and dermatitis are well established. In terms of numbers the main problem is dermatitis. DHSS figures show about 700 people per year in the engineering industry claiming benefits because of this. These are the most serious cases, there are no doubt many more who have less serious problems or who suffer in silence. There are only a handful of claims each year for the more serious skin cancer conditions.

The Guidance Note will also deal with work with refined oils, and fluids in which nitrosamines, and microbial or endotoxin contamination may occur, even though the level of risk is less well understood. In the field of microbial contamination HSE has commissioned a research project and a local initiative is also being carried out in one of our Areas by HM Inspectors of Factories in association with the Employment Medical Advisory Service.

(b) Control

One means of control of exposure which may be necessary is the wearing of protective equipment, eg. gloves. One problem area is that operators wearing gloves appear to be more likely to be involved in accidents involving entanglement at rotating machinery and it has been a recommendation of the Inspectorate that gloves should not be worn for these operations. This is now being reviewed. Clearly the first steps are to reduce as far as possible the three risks, of entanglement, swarf cuts and skin contamination, by guarding, swarf removal tools, and reducing contact with the fluid. If the risks other than entanglement then predominate, gloves may be worn. It is sensible to wear a glove which if entangled tears easily, eg., nitrile glove in preference to leather or textile ones.

HSE has commissioned research at Manchester Materials Science Centre to look at the possibility of developing improved gloves which are less likely to "snag" and if entangled, tear easily. They should also be able to stand up to wear and tear and resist penetration by cutting fluid or its contaminants.

A previous session has dealt with the inhalation of oil mist. The setting of appropriate exposure limits is an extremely complex problem. As there is no likelihood of the present Occupational Exposure Limit of 5 mgm^{-3} being revised in the near future the Guidance Note will continue to quote this figure and will include a recommended method for its determination.

(c) Training

The guidance note will emphasis the need for training. It is important that employees should understand the hazards so that they appreciate the precautions laid down for handling new and used fluids, the control techniques, protective equipment, personal hygiene, reporting medical problems.

Training should include first-aid as incorrect procedure can cause additional damage particularly where the eyes are splashed with fluid.

INTRODUCTION TO PLENARY PANEL DISCUSSION

Mr.M Piney

Before the Panel discussion begins I would like to make some observations.

Firstly, I had a horrible fear at the start of the Conference that the industry based speakers in particular, would clam up and not join in the debate for fear of revealing information or policy to their competitors. That has not happened and the debate has been very open and lively. I thank you for that.

Secondly, there is a group missing from this Conference who have been mentioned by a number of speakers and this group is the machine tool manufacturers. (Editor - Papers addressing the question of machine tool design were solicited after the Conference).

Thirdly, I was very struck by one of the statements from Mr Pat Ruane, he said :

" The impact of actual or proposed legislation preventing or restricting the use of certain additives as often led to rapid development of a wide range of alternatives from an alert and responsive cutting fluid supply industry. Where formulators have previously had only a handful of additives suitable for effecting a particular operation, there may now be several hundred. Additives which were considered irreplaceable in their day have now been replaced as a matter of course, and attention has moved on to meet the next challenge."

This is a very optimistic and proactive outlook. If there is one message I will take away from this conference it is the very clear need for more research into occupational asthma related to cutting fluids, bacterial contamination, the role of endotoxins and the etiology of dermatitis. If Mr Ruane is right then once the causes of the health effects have been identified then the oil formulation industry can and will respond. The research needs to be done however. For instance, seven years on from a Conference on bacterial contamination of cutting fluids organised at Aston University our understanding of the health effects, (if these exist), of bacterially contaminated oils has not progressed much further. The need for further research is urgent.

Lastly I would like to leave you with a final message: Please go away from this Conference, mull over what you have heard, perhaps alter your views on the health hazards of cutting oils and their control and change your policies and practice.

I will now throw the Conference open to questions covering all aspects of this subject to the Panel.

Questions

Mr.E.Hill Cardiff It has been mentioned already particularly by Gerry Lee that the oil mist technology only involves at the moment legislatively the oil content and nothing else which is why I wondered whether the Castrol people would like to comment on what they would like to see measured as an aerosol. For example I mentioned glycols, would glycols be a sensible thing to look at in the air to get some idea of how much of the synthetic fluids are being aerosolised.

Mr.P.Oates The answer is yes, Ted, if the cutting fluid has glycol in it we have determined for some of the newer products, the actual shall we say Threshold Limiting Concentration, using a hundred fold factor by aerosol mist studies on the cutting fluid emulsion. You could not measure that by glycol there is very little glycol in the formulation. If you are talking about a pure synthetic that contains glycol, thats a possibility. I think you have to study each cutting fluid to decide what you are going to measure its not like with a neat cutting oil you have the mineral oil there which is the carrier for the additives. In a soluble oil its the water that is there as the carrier you can't measure water because its all around us.

Dr.P.C.Elmes Cardiff Can you measure by silica gel?

Mr.Oates Measure water yes.

Dr.Elmes You said you can't measure water.

Mr.Oates Measure but its coming from the atmosphere as well.

Mr.G.Lee We've done this particular thing taking a background sample with a silica gel tube outside the environment and then we measured beside the grinding machine. We got an enormous number... we didn't know what to do with it but we got it!

Mr.Oates All you are measuring there is the increased concentration of vapour in the atmosphere. You are not necessarily measuring the coolant it could be just the process. You are producing a lot more water vapour so you are not actually measuring what you want to establish.

Dr.Elmes Concerning exposure limits that you have got at the moment and that you say you are not going to alter, well if you are dealing simply with the plain oil, the neat oil mists that with the various things that they put into the neat oils now, it seems to be a very high limit by current standards bearing in mind that it was based on a very peculiar oil that we used in America umpteen years ago. Ought not you to be looking at a lower standard? We have heard from industry that they could cope with a lower standard in fact would like it in some respects. The other half of that question was, you are not really looking at the concentration of the aqueous mists in the air at all by your recommended methods of measurement, all you are measuring, as we have just heard, is the oil fraction which is a nonsense really. If you want to know how much coolant is getting into the chaps lungs you are only measuring 5% of it so I'm told, from what I have heard in the last two days. The third question is that the industry responded to the PCA problem very rapidly does the oil Guidance Note in fact include any recommendations about PCAs?

Dr.N.J.T.Long If I could take the first point about the OEL for oil mists we are of course aware that there are limitations in this. I have asked our policy section when the OEL is going to be reviewed and I've been told it will not be before 1989. There is too much already on the agenda. Again I think I shall have to go back and ask again about the measuring method because I think that is an issue that's been brought home to me today. It was our intention just to put the normal method of measuring oil mist in the Guidance Note. I think that is a very good point. Concerning PCAs, we will state that solvent refined oils should be used but I don't think we are going to be putting in any specific level of PCAs in the oil that one should have or one should avoid. Do you think we should put in an actual level to be achieved by the suppliers?

Mr.Oates Nobody can actually define a method that will tie up with the potential carcinogenicity or tumourogenicity of an oil. One can have one product with a very low PCA level that is tumourogenic. Another oil with a higher level that is not. No one has yet been able to define an actual PCA standard and that's the problem.

Dr.Elmes But my point is that you have got to give the user some method of checking on whether the supplied material does in fact conform to the recommendation. One would know, one would hope, that it was not a dangerous PCA that was there but have you got to have a test that can be applied to materials being submitted for use in this country from all over the world?

Mr.Oates The answer is that the only test at the present time to establish carcinogenicity is animal testing.

Mr.R.J.Reynolds Health and Safety Executive. My question is to Nigel Long perhaps also to Mr.Lee, in your experience about how many of the companies that you inspect actually issue their work people with overalls and then take responsibility for laundering them and giving the men clean overalls either every shift or every week?

Dr.Long The answer to that is very few indeed amongst the larger companies higher proportion as you might expect amongst the smaller ones the performance is very poor I can't give you any actual percentages there.

Mr.Lee Well as far as my company is concerned, overalls are supplied and laundered every week (as appropriate as to the contamination).

Mr.J.D.Hampson Stirling Winthrop Group. Once again the biocide manufacturing industry has been the whipping boy without any chance of reply. You did mention that the machine tool manufacturers would perhaps be requested to issue a paper. Perhaps at some future meeting of this sort, a biocide manufacturer of repute could be also asked to give a paper. We are not cowboy companies, we do an awful lot of research all the products from the reputable companies have sufficient safety data, toxicology data to satisfy most people. Dermatologists themselves seem very split on this subject There was a product mentioned by name yesterday Grotan, the last paper I saw published on the irritancy of Grotan was done with a patch test of 10%, anybody who attaches any credence to that sort of work does not know what they are talking about. If a man goes to a doctor and he's recommended to have three aspirin, he does not take three hundred and expect to have no problem. The cosmetic industry are doing an awful lot of work and they are one of the major users of preservatives. The oil industry also uses isothiazolines. There were three papers published at the end of last year in Contact Dermatitis, the first was, I think in October. There was a paper published in Sweden where they were finding 4% of the population sensitized to isothiazolines from a particular moisturising cream. In December there was a third paper published in Holland where similar findings were observed but sandwiched in between there was a paper from the States where a baby oil preserved with isothiazoline was found to be completely innocuous by another dermatologist. So the cosmetic industry does not agree within itself. I think to have a dermatologist saying things without right of reply and people making note of this in the industry is not very fair.

Mr.Piney I'm sorry if you feel unfairly treated you did have the right of reply in the sense that you could have replied to Dr. Rycroft when he was here.

Mr.Hampson I was not here in the morning and he was not here in the afternoon.

Mr.Piney No that's true he had to leave in the morning.

Unidentified Speaker Dr. Long, you mentioned in your paper on COSHH that it is interesting to see that non-solvent refined mineral oils are included in the proposed list of carcinogens. Does this mean that severely hydrogenated oils that are currently used in water, certainly water extendible cutting fluids, will be treated as carcinogens?

Dr.Long I can't answer, I assumed that it referred to neat oils but that is perhaps something that will be clarified in the Code of Practice to accompany the Regulations.

Mr.A.J.Riley BP. I'd like to ask the whole panel a question on the occupational exposure limits for mineral oils and also cutting fluids. It is quoted as 5 milligrams per m^3 for the oil mist level which is a total particulate exposure. Should we be looking more at respirable fraction which is actually what people are going to be exposed to and inhaling and possibly that is causing damage or should we be sticking to total particulate?

Mr.Lee I think it is more or less all inhalable, the droplet size of an oil mists that I encounter are about two microns in diameter. I would imagine most of that is respirable. Although I am not an expert in this area.

Mr.Riley Is that actually oil mist in a general environment or close to machines then because

Mr.Lee Its the oil mist that people are exposed to, personal measurements on the worker.

Mr.H.Krebs Henkel Dusseldorf Germany. I was asked by Mark Piney to expand the very specific questions that I raised yesterday. Firstly, the question on the build up of nitrites, we know that non-nitrate containing products will create, during the application, about 10 to 25ppm nitrite. The automotive industry which always tries to be first in Germany wants to eliminate even this small amount (which you can't compare with the amount of nitrite the customer had when using nitrite containing products). Secondly was the concentration of cobalt diluted in grinding fluids for hard metal and it was pointed out by Mr.Ruane that concentrations of 40 to 50ppm have been found. There is a big tool manufacturer in Germany who has an internal rule or regulation that the cobalt concentration in the grinding fluid should not exceed 5ppm and they run a big system about 90 cubic metres for one year so there must be products in the field which fit this application and there are suitable products.

Mr.Ruane I would like to answer that, I think it deserves some semblance of reply anyway. The level of cobalt is very dependant on the design of the machine and also the actual level of spray of coolant onto the actual hard metal pieces. Having said that, the level that you talk about does surprise me, quite substantially because certainly in most of the tests that I have seen pure water gives a higher figure than that.

Dr.S.D.Robertson Shell Some information for Mr.Oates and others, I don't know whether its a question of great minds think alike.. I won't finish that one but we did a similar test programme on Legionella and we came up with exactly the same conclusions as you did, which may be of use and some encouragement to you. Again through an independent laboratory we came up with exactly the same results limited by ability, non-identified in coolants that we had obtained from various customers and the challenge tests were of a similar very short lifetime. I wonder if I could possibly make a comment to the gentlemen from Rocol, I share his concern about the question of PCAs and base oils. I wonder whether we are getting a bit too hung up on the expression 'solvent refined oil' there are other ways of achieving low levels of PCAs, analysed by a DMSO method or the I.P. method. It does not really matter whether you solvent refine or whether you hydrotreat provided you get to an acceptable base oil. I am a little bit worried that people might think that only of solvent refined oils which could be a problem for the supplier.

Mr.Ruane Just a quick comment from my own point of view. In both the papers that I have written you will find that when I talk about oils treated to reduce the level of PCA I have mentioned both solvent refining and deep hydro treatment.

Mr.Oates Sorry I was going to comment. Outside the petroleum industry the expression everybody knows is solvent refined. One can expand as solvent refined or deep hydrogenation, oleum treated. Yes I put in the expression that was used by the IP twenty years ago.

Dr.Holland Elliott GEC Manchester Can I ask the HSE whether there have been any prosecutions regarding abuse of the Health and Safety at Work Regulations as a result of exposure cutting oils and if not, how do you propose to influence some of the very small companies in which a great many people will be exposed now and in the future?

Dr.Long I don't know of any prosecutions of firms to do with cutting oils. I think that is perhaps something to do with proving cause and effect in that industry. Perhaps the only hope is that COSHH lays down things to do making it easier to prosecute. You can prosecute for systems failures rather than for actual failure to take precautions so perhaps if we can get people to set up systems that has more hope.

Mrs.S.Stimson CEGB I'd like to ask Dr. Long if he has any control as an HSE person over the GPs reporting of dermatitis, industrial dermatitis or anything related to cutting oils, and why it has been left off RIDDOR.

Dr.Long I would guess that the reason it has been left off RIDDOR is that there is so many cases reported that we would be absolutely snowed under. There are quite a lot of interesting things that have been left off RIDDOR perhaps either because there are so few that it is thought that people would forget to report them because the cases occur so seldom or because they are so common that we would be snowed under. Hard metal disease is not reportable under RIDDOR. As HSE ultimately we could ask for the regulations to be changed but I don't expect to happen for some years. Then the current regulations can be reviewed and we can look for things that can be taken in and things that can be taken out.

Mr.Piney I've got a couple of questions first to Gerry Lee, I know that as you told me before that you did have a problem with hard metal disease and it was a wet process that people felt that it was under control could you just describe it because I think its informative.

Mr.Lee Two of the slides I showed were of a wet grinding machine associated with the occurance of hard metal disease. It is not a particularly easy matter to investigate but in general terms it has been our observation that the concentration of cobalt and cemented carbide dust around wet grinding processes have been higher without extraction than with dry grinding machines which have perhaps mediocre extraction. That would have been perhaps twenty years ago, and as a result of this we investigated methods of trying to prevent the release of aerosols to air. We devised extraction systems to be applied directly to the grinding wheel both of wet and dry grinding machines and the result is a very much lower level of cobalt dust in the air. I am told by the medical officers that the serial lung examinations showed no changes. We concluded from our investigations including some limited epidemiology, that exposures to aerosols from wet grinding machines may be more significant in terms of causing disease (at least in the user industry I would not presume to speak about the carbide manufacturing industry).

Ms.D.Glass Institute of Occupational Health I wanted to ask if anyone here knew a laboratory that would do analysis for polycyclics in used oil or recycled oil. I have not been able to find anyone who would do it for love or money.

Mr.P.Oates The answer is Grimmer Hamburg.

Mr.Piney My question to Ray Weaver was about boron containing fluids and the question is are they sterile? And if they are not sterile what sort of microbiological load do they contain?

Mr.R.Weaver I've seen them with levels as high as 10^6 or 10^7. The ones we are currently selling could be expected to support a level of up to ten to the five with no apparent problems. I say that because for most end users of coolant, if there is no apparent problem then they probably won't bother to check for things like bacterial level. We check as a matter of course but unless there is some result from an over-high bacterial level I think a lot of people won't worry about it anyway. They are certainly not sterile I think you can expect a background reading of bacteria that can in fact be very very high.

Dr.M.D.Brown Boots Microcheck. I wonder if I can come back to Ray Weaver on that very point, he says that he checks the level of contamination of bacteria in the fluids. In his talk he dwelt on extending the life of fluids which I can see from an end users point of view is going to be the thing that is required.

Mr.Weaver Its one of the things he wants.

Dr.Brown OK what sort of level of bacterial contamination concerns you and what do you do about it?

Mr.Weaver We're concerned to avoid levels of bacteria that would give rise to certain problems whether its human, machine, or component problems. And what do we do to prevent it? We hope that people will put not just our fluids but everybody's fluids into conditions that are as clean as possible and run the fluids in conjunction with our recommendations. We as a company choose not to post-treat. I am open about it there you are we don't post treat our fluids because we find it practically impossible even to get our customers to run the fluids at the correct percentage, and if they can't do even this I think it is unwise of us to expect them to post-treat even in conjunction with correct recommendations, so we are basically trying to offer somebody coolant that they put into a machine that they then treat as well as possible for as long as possible. So I don't have post-treatment as one of the weapons in our armoury.

Dr.Brown I appreciate that and apologise for jumping on you perhaps I can ask the panel in general because one of the things you say is that you want to avoid levels of contamination that are likely to be damaging to the people who are using it what is that level of contamination that is potentially worrying what level does it become a concern.

Mr.Weaver Have we had proof in the last two days that there is a level that causes concern? I think what we would take note about is if we saw a level of contamination or a type of bacteria present which would cause changes in the emulsion eg lowering a pH, or finding coliform bacteria. You would want to kill this type rather than killing a certain type that at a particular level appears to be quite satisfactory and is not degrading the emulsion.

Dr.J.Parr NIPA Laboratories I was going to ask basically the same question as Dr.Brown asked but just to take it one step further and to be perhaps a little bit contentious. The biostable fluids which as I understand it were allowed to support a certain level of bacterial growth and sometimes perhaps some fungi as well, which is more of a problem to user? Is it fair to ask a man in the working environment who may have stressed skin and dermatitis from the defatting action to spend up to eight hours a day with his hands being covered with fluids containing 10^6 bacteria per ml, in a case of a cosmetic as Ted Hill's analogy this morning I don't think we'd be happy if our shampoos contained 10^6 bacteria per ml which is used for just a few minutes a day.

Mr.Ruane I think initially there are two sections to that question. The first one to some extent can be put forward to the actual supplier of the coolant. In the context of the actual situation you outlined I would say to you no it is not fair to put a man with dermatitis into a situation where he is operating eight hours a day in a coolant that is unsatisfactory from his point of view anyway. I think Dr. Rycroft yesterday was talking about the importance of having people in operations which they can continue to carry out. Having said that, there is no great merit in a situation where you keep somebody in the same job purely to keep him employed. The other aspect of this issue is the attitude of the company involved. Most of the companies that I have had experience of where they have had instances of dermatitis, and its fair to say that in large companies where you have a large number of operatives there is always, likely to be one operative who is going to suffer a contact allergy from virtually any fluid thats introduced, are usually fairly sympathetic. They will usually try and move the man away from the machine, the coolant or the types of operation which require the use of an emulsion and move him on to perhaps a neat oil based operation or a dry job to prevent this sort of thing happening. In my experience the sort of situation that you talk about is not that widespread.

Mr.M.Hall Sandvik When you are taking tests for bacteria and pH either from the coolant or the tank does that level remain constant through out the depth of the tank or does it settle if so wouldn't it be more appropriate to take the sample from the point of discharge of to the machine.

Mr.Oates When you asked that question I noticed Ted Hill smile very discreetly, I see he has the microphone let him be the first to answer the question .

Mr.Hill Cardiff. First of all as I said yesterday there is a tremendous distribution of organisms throughout a fluid and no one sample tells you everything about it and we have published papers about this. I was going to comment on the numbers of organisms because I don't think that there is ever going to be a magic figure I always start out by thinking that milk at the doorstep has got roughly 50,000 bacteria per ml and why should we expect cutting fluids to be any better so there is a base line below which we can forget about microorganisms and that is probably 50,000 or even a 100,000 organisms, that is the normal level of contaminated fluids which are about us like milk. Now on the total number of organisms I think we first of all consider total number and possible hazardous organisms. The two that I worry about most are Pseudomonas aeruginosa which is very easy to recognise and is a known producer of keratinolase which I said yesterday is known to soften the skin I think its stupid to have cutting fluids with an enzyme in them which is known to have an effect on the skin and presumably allows it to be more sensitive to other chemicals. So I always worry about high levels of Pseudomonas aeruginosa. I also worry about high levels of sulphate reducing bacteria producing a lot of sulphide. In the first case it is unpleasant and it could be dangerous. So these are two organisms I worry specifically about. On the higher total levels which have been discussed. Is 10^7 or 10^8 acceptable? I said yesterday that we are bombarding ourselves with enormous amounts of endotoxins when we are around a grinding machine and I think its not very clever to go on doing this and I would worry about having very large numbers of organisms in a fluid which was creating a large inhalable aerosol. One thing which strikes me very clearly is that there is a gap in our knowledge, somebody quoted three papers about sensitization to a specific chemical, all contradicting themselves. What we lack is the knowledge about formulations because these chemical are not there as 100% pure compounds but they are in a formulation. They are there in something which either encourages them to go through the skin or prevents them going through the skin. The same chemical can act quite differently and have quite different concentration coefficients under the influence of other agents and I am sure the pharmacology industry is full of information about this as drugs are administered through the skin. But this information does not seem to have filtered down to us dealing with metal working fluids. I think we need to know a lot more about the effect of formulations on the permeability of the skin to chemicals which are known to be sensitizers or carcinogens.

Mr.Piney Many thanks Ted. I think I agree with you and with what Pat Ruane was saying, we need a solution to some of these problems. A multidisciplinary research team is needed, no one discipline is going to give us the answers.

Mr.C.Packham Reinol-Janet(UK) Is it fair to ask a man to have his hands in coolant for eight hours a day with or without dermatitis? I would be very worried indeed if anybody had their hands in coolant for eight hours day I think they would be asking for trouble and we should certainly be looking at ways in reducing contact. We say avoid unnecessary contact, one of the things that I notice and it's not so much on new machines but certainly on older machines is that coolant is frequently flowing when the machine is at a standstill and the individuals are actually inserting or removing components. It is a very simple matter just to cut the flow of coolant off at that point and that substantially reduces contact.

Mr.Oates When somebody is centreless grinding to a tenth of a thou he's got his hand in feeling the component as he is grinding, and that is where you see eight hour a day contact.

Mr.Piney I am going to draw the conference to a close now although I think we could go on talking for sometime. I've certainly learnt a large amount in the last two days I hope that you have enjoyed it and that you enjoy reading the Proceedings when they are eventually published. Thank you for attending.

THE USE OF BIOCIDES/PRESERVATIVES IN INDUSTRY

J Derek Hampson - Sales Controller, Sterling-Winthrop Group, Biocides Department

In a normal environment, wherever there is water and a food source, micro-organisms will occur and proliferate. In commercial markets such as food, paints, cosmetics and petroleum products, the presence of micro-organisms (bacteria, yeasts and fungi) produces a break down of substances in the product usually resulting in undesirable side effects. This process of "biodeterioration" causes the spoilage of foodstuffs making them unfit for consumption, in emulsion paints the result of microbial contamination is the breakdown of gel structure, discolouration, gassing causing by anaerobic sulphur reducing bacteria and fungal growth on the surface of the product in the pack. Similar biodeterioration occurs in cosmetics, water based adhesives and other emulsion type products. Without the use of a preservative the result of this contamination would be huge losses caused by spoiled, unsaleable product.

The petroleum industry has a slight advantage, in that the majority of products will withstand a certain level of microbial contamination without any adverse effect in performance. If, however, the contamination was allowed to be unchecked, it would only be a matter of days before adverse effects become apparent. In an ideal environment, contamination levels of 10^3 can exceed 10^7 in a matter of hours.

Water soluble oils, semi-synthetic and synthetic coolants and aqueous dispersions are all potential breeding grounds for a variety of micro-organisms and the use of a Biocide is required to stop their uncontrolled growth and resulting problems. This also applies to the "bio-stable" class of fluids which, although able to control the effect of fairly high levels of bacterial contamination, may be susceptible to fungal contamination.

Contamination is introduced into a system by airborne micro-organisms, particularly yeasts and moulds, but by far the most direct method of contamination is by bad working practices and a dirty environment. It is common to find the floor area around machines inches deep in litter of old swarf, cigarette stubs, discarded rags and the remains of sandwiches. Lack of personal hygiene can also be a cause of contamination, failing to wash hands after using the toilet can result in the introduction of coliform bacteria into a system where numbers will increase rapidly in the ideal breeding conditions present.

Typical problems related to contamination include;

1. Offensive "Monday morning" smell due to the presence of anaerobic SRBs (sulphur reducing bacteria). The production of hydrogen sulphide by these bacteria is in itself a hazard to health.

2. Breakdown of the emulsion resulting in loss of lubrication properties.

3. Destruction of corrosion inhibitors resulting in the rapid rusting of machined components, machine tools and the machinery itself.

4. Clogging of filters, slipways and pipework.

5. Shorter coolant life resulting in increased machine downtime with the associated increase in production costs.

Questions could also be raised on the hazards to health associated with the presence of high levels of bacterial some of which are known to be pathogenic, in the working environment.

The controlled use of a Biocide will eliminate the results of microbial contamination. To formulate good working practices in order to overcome the risk of microbial spoilage, it must be remembered that prior to the dumping of used coolant and recharging with fresh, the machine must be thoroughly cleaned and disinfected to eliminate the carry over of the contamination to the fresh charge. The use of a system cleaner containing a Biocide will reduce the risk of recontamination. The cleaner should be added to the dirty system at least 8 hours before the change, the machine can operate as normal during this time.

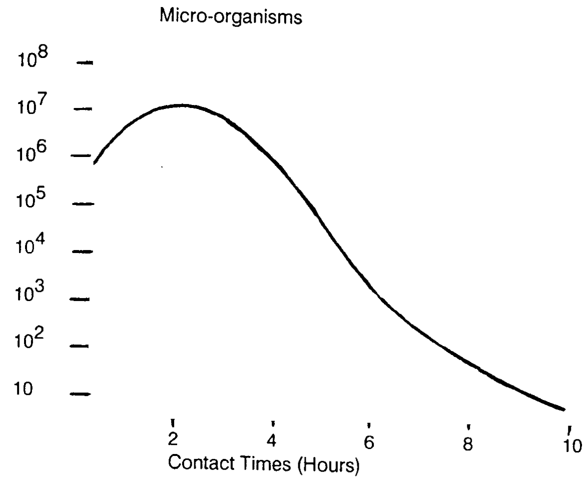

Fig.1 Diagrammatic course of Micro-organism count using Grotanol SR1 during the cleaning of a machine

If time is available, it is recommended that the system is flushed out with clean water before adding the fresh charge of coolant. This is to remove the dirt and slime loosened in the cleaning process.

Most oil blenders incorporate a Biocide into the emulsion concentrates but the effectiveness of this, once the coolant has been diluted for use, depends on the coolant formulation and the quality of the Biocide. If should be remembered that post-treatment with a Biocide must not be done on an uncontrolled basis, advice should be taken from the oil supplier or from a Biocide manufacturer who will, with prior knowledge of the coolant involved, recommend the Biocide suitable for that particular product. In these days of complex coolant formulations, there is no such thing as a general purpose Biocide and care must be taken in the selection of the one to use. For example, if a coolant uses nitrates as a corrosion inhibitor, an amine containing Biocide must not be used because of the risk of potentially harmful nitrosamines being formed. On the other hand, if the coolant contains amines these could in activate certain isothiazolinone containing Biocides. It cannot be over emphasised that the use of any Biocide must be controlled by a responsible person. Used correctly, they can be a boon to the engineering workshop, improving the profitability by the reduction in oil costs and machine down time and improving the quality of machined parts, used incorrectly they can cause problems, skin irritation for one. Reference must be made to a particular machine shop where the Biocide was entrusted to the tender care of the man with a trolley who swept round the machines, spread the oil absorbed granules, issued clean hand rags, and before moving on to the next machine, "glugged" some Grotan BK into the sump. This would happen two or three times a day. Good for Biocide sales but overwork for the medical room investigating the high incidence of sore hands!

Reputable Biocide manufacturers spend a lot of research time and money to ensure that a product is safe if used correctly but it must be remembered that these are potent chemicals and must be treated with respect.

A fairly quick and cheap way of assessing the level of contamination in a machine is by the use of a dip-slide. If the "bug" count on a slide shows a count of, say, 10^5, it can be assumed that the level of Biocide present has dropped and is no longer having an effect, at which time the machine should be re-dosed at the recommended use level. Failure to maintain an effective Biocide level will result in contamination reaching the level at which degradation of the coolant will occur rapidly. When this stage is reached, a Biocide will kill off the contamination but will not reverse the damage already done to the properties of the coolant.

To summarise, soluble oils and coolants provide an ideal breeding ground for micro-organisms, with levels of 10^7 of a cocktail of bacteria (aerobic and anaerobic) and fungi often found. This contamination destroys the properties of the oil resulting in poor machining performance and high coolant replacement costs. A Biocide, used correctly and only after it is evaluated for compatibility with the coolant, will prevent the growth of contamination in a system with a resultant saving in costs. Prior to changing the coolant in a machine, a disinfectant system cleaner should be used to prevent the carry over of contamination into the fresh charge. Biocides, by their nature, can cause skin irritation if used incorrectly or overused. Dosing of a system must be strictly in line with the manufacturers have a technical service and microbiology laboratory available to provide reports on contamination levels and recommendations as to the Biocide most suitable for use.

MACHINE TOOL DESIGN AND ITS EFFECTS ON THE DEGRADATION OF CUTTING FLUIDS

Ray Weaver - Market Manager de la Pena Oil Ltd

Is the cutting fluid manufacturer's job really finished once the end-user has been supplied with the correct coolant for the job together with advice on how to aim for optimum coolant performance and sump life? Probably not, in the light of certain aspects of machine tool design.

There is a case for on going lobbying of machine tool designers in general to take the requirements of cutting fluids into account more sympathetically, as part of the industry-wide effort to help the end-user to maintain the cutting fluids within reasonable standards of performance and quality. These brief notes hope to suggest how improved attention to certain machine tool design aspects might exert a more positive effect on cutting fluid and its ultimate degradation in use.

The problems of unsatisfactory (from a coolant viewpoint) machine tool design are not new: the inaccessible, uncleanable coolant sump, bad smelling and discouraging further exploration, has created for decades a vicious circle of stench and neglect. Lube oil and swarf have always obeyed gravity's draw, making their way down into coolant sumps hidden within the bowels of the machine tool, there to remain and help to degrade the coolant.

Consider for a moment two traditional machine tools and some of their design features:

1. A toolroom knee-and-column-type milling machine. The small access holes in the base of the machine deny easy access to the coolant. Internal ribbing in the base creates blind pockets which harbour fungus and resist practical attempts at cleaning and sterilising. Finally, a coolant mist generating device delivers purpose made aerosols of coolant directly into the face of the operator.

2. A manually operated lathe. Spray and aerosols of coolant are directed at the operator, and access to the coolant sump is not always easy. In both instances, serious consideration should be given to the implications of mist and aerosol-generating situations. Many coolant health and safety sheets appear to ignore the implications of inhalation altogether, never mind the implications of inhaling coolant aerosols infected by the bacteria, etc in the sump. Regarding these traditional, manually operated machines, in the absence of company policy ensuring meticulous, regular cleaning out and filling with quality coolant, we can make no better suggestion than to fill the sumps with concrete and instead store the coolant at floor level in a separate, well-ventilated prefabricated tray with easily removed loose fitting lid to allow good airflow across the coolant surface. Easy access for cleaning is the main benefit, although the limited space available in many factories makes this proposal for separate sumps nothing more than a pipedream.

Machine tools offering leading edge technology tend, regrettably, to be no better than the knee-and-column millers of twenty years ago in the way they treat and help to degrade coolants.

High ambient temperature, over-abundant lubrication and large volumes of swarf make some modern machines even worse than the average manually-operated lathe.

The following machine tool features can have an impact on the degradation of cutting fluids:

a) Rigid, fixed guarding making rapid access for machine cleaning difficult

b) High speed spindles generating coolant aerosols and foam

c) Through-the-tool coolant feed, demanding filtration fine enough to plate out antifoam from the coolant

d) Inaccessible coolant holding tanks, often warm and oily increase cleaning difficulties

e) Integral filtration which can promote plating out of antifoam

f) Swarf conveyors, often difficult and time-consuming to dismantle for cleaning and sterilising

g) Gulleys and pipework beyond the reach of mechanical cleaning devices make thorough cleaning impossible

The COSHH Regulations coming into force on 1st October 1989 will make it even more advisable than before to maintain coolant in good condition, and to use suitable guards and other protective devices such as local extraction equipment to combat hazards in the workplace. It is to be hoped that such guards and extractors can be designed so as to be efficient but easily removable for access and cleaning.

Long-life coolants designed to be capable of staying in the machine tool for periods of one year or more need to have the swarf and tramp oil which gradually builds up removed regularly. This ensures that the maximum sump capacity is taken up by coolant, not swarf, that a large percentage of bacteria may be removed with the swarf, and that dissimilar metals in the coolant do not lead to electrochemical splitting of the coolant.

From the coolant maker's point of view, therefore, the need is for the machine tool to be designed to be well guarded (adequate but not impregnable), offering suitable protection to operatives against both splashes and aerosols. Ideally, each individual machine would be fitted with oil mist extraction equipment (a brief look at the constituents of a typical coolant will certainly discourage inhalation).

The second requirement is to have effortless access to the coolant, preferably via a separate, easily cleaned and sterilised tank with loose-fitting lid encouraging sufficient airflow across the surface, and allowing convenient removal of tramp oil using skimmers, oil wheels or the de la Pena Freddy - type sump cleaners.

The third requirement is for machine parts such as guards and swarf conveyors to be designed for easy, rapid dismantling (minutes not hours) so that necessary physical cleanouts can be done with an absolute minimum of downtime.

Until such time as more coolant-friendly machine tool designs begin to appear, there will continue to be excessive degradation of coolants due to the influence of their immediate environment: the uncleaned becoming the uncleanable, and vice versa; the failure to prevent losses of large volumes of lubricating and other oils into the coolant system; and the understandable refusal of production-oriented managers to take machines apart, clean and re-assemble the system.

THE CONTRIBUTION OF MACHINE TOOL DESIGN TO THE CONTROL OF EXPOSURE TO CUTTING FLUIDS - PROBLEMS AND CONFLICTS.

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There is an old (but true) cliche "All design is a compromise". Its importance has never been greater than today, when increasing pressures are being laid at the door of the Machine Tool Designer to consider many new factors within the design process, while the influence of some of the other well established design factors is changed.

Some of the basic factors which have to be considered are:

The product must work, it must work efficiently, economically and be adaptable enough to be uprated wherever possible to take advantage of new technologies and processes.

The product must also be safe in operation, i.e. not present hazards to the operator, other workers, or even visitors to the workshops who may be in the near vicinity. It must also be easy, non-hazardous, and ergonomically convenient to use.

Finally, it must be economical to make, i.e. the maker must be able to sell the product, and made a profit.

We will now concentrate on the aspects of safety together with the other related aspects which have a bearing on or are affected by safety aspects.

The overriding requirement of safety legislation is provided by the Health and Safety at Work, etc. Act which broadly requires that all workers shall be able to work in safe conditions and hence that all machines provided for their use shall not create any hazards. Remember, hazards may take many forms: mechanical, chemical, noise, etc. This legislation is to be reinforced at the end of 1992 by the implementation of the EC Machines Directive which generally says the same thing but imposes additional conditions of machine certification procedures, essential safety requirements (ESRs) and reference to Harmonised European (CEN) Safety Standards.

EC Directive Machines

ESRs Annex 1 Clause 1.6.4. Operator Intervention.

"Machinery must be so designed, constructed and equipped that the need for operator intervention is limited.

If operator intervention cannot be avoided, it must be possible to carry it out easily and <u>in safety</u>".

Annex V EC Declaration of Conformity.

Before drawing up the EC declaration of conformity, the manufacturer, or his authorised representative in the Community, shall have ensured and be able to guarantee that the documentation listed below is and will remain available on his premises for any inspection purposes:

A technical construction file comprising:

- an overall drawing of the machinery together with drawings of the control circuits;

- full detailed drawings, accompanied by any calculation notes, test results, etc. required to check the conformity of the machinery with the essential health and safety requirements;

A list of:

- the essential requirements of this Directive;
- standards, and
- other technical specifications;

which were used when the machinery was designed;

- a description of methods adopted to eliminate hazards presented by the machinery;

- if he so desires, any technical report or certificate obtained from a competent body or laboratory[1];

- a copy of the instructions for the machinery,

- if he declares conformity with a harmonised standard which provides therefore, any technical report giving the results of tests carried out at his choice either by himself or by a competent body or laboratory[1].

(1) A body or laboratory is presumed competent if it meets the assessment criteria laid down in the relevant harmonised standards.

Note in particular the heavily underlined parts of the Directive.

The full and final text of the Directive has now been published in The Official Journal of the European Communities - 29 June, 1989 - OJ L 183.

The rate of development of Safety Standards has increased in recent years, within U.K. for instance the first edition of CP 3004 Guarding of Machinery in 1964 was a very slim publication. It was followed by a revision published as BS 5304 : 1975 - Safeguarding of Machinery and after some 8 years of revision the latest version BS 5304 : 1988 Safety of Machinery was launched in May, 1988. It is now an impressive hard backed volume of 158 pages which must be regarded as the standard reference text of U.K. Machinery Safety Engineering.

It has had an effect beyond the shores of the U.K. also, a German language version has just been published, and a near final text was submitted to the European Standards Body - CEN whose Technical Committee TC114 Safety of Machinery working group WG1 was considering the requirements of the European Standard on basic safety concepts. It will be of no surprise to hear therefore that the draft European Safety Standard pr EN 292 which is about to be circulated to CEN member bodies for the voting procedure, bears a very strong family resemblance to the British Standard BS 5304 : 1988 even though it is devoid of the excellent illustrations of the latter.

What has this to do with the control of Exposure to Cutting Fluids? Within the standards there is a recommendation, rather a requirement, that adequate consideration must be given to safety throughout all phases of the machine's life though the initial build, transport, erection, installation, testing, use, maintenance and repair, to final dismantling and disposal.

Thus the machine tool designer must give consideration to all potential or possible uses of the product, and of course this must also mean the protection of the operator against the potential harmful effects of coolants and cutting fluids.

Some twenty years ago there were reported cases of scrotal cancer being caused by exposure to cutting fluids. They were reputed to have been caused by setters and/or operators virtually living in oil soaked overalls with oily rags kept in their pockets.

At the time it was claimed that improved personal hygiene was required, impervious aprons, etc. and measures were taken to ensure containment of the oil splashes. The problems were compounded by the use of higher cutting speeds on the machines which resulted in increased splashing additionally by an atomisation of oil droplets which literally coated the inside of the workshop.

Oil mist was reduced by the use of extractors and condensing devices but the problem was further alleviated by the development of cutting fluids particularly semi-synthetic and synthetic fluids which were non-carcinogenic. Even this was no final solution for the machine tool designer because the new fluids also proved to be excellent paint strippers - forcing manufacturers to change from their previously used enamels to polyurethane and epoxy type finishes. Additionally they were good at removing oil from surfaces of the machine and finished components - some users experienced premature wear of machines and had to invest in inter-operation rust prevention exercises for ferrous workpieces.

The lesson to be gained from these experiences is that any change to the status quo must be thoroughly and adequately researched to ensure that all side effects are discovered and included in the economic justification for the proposed change.

The above views are the personal thoughts and recollections of the author, who wishes to thank the management of AMTRI, his employers, for permission to contribute this article.

INDEX

The underlined figures are the main topic of the paper

BIBLIOGRAPHY ON OCCUPATIONAL EXPOSURE TO OILS

This bibliography has been prepared by searching the NIOSHTIC database of health and safety information, supplied on the OSHROM compact disk by Silver Plattter Limited.

Contact Allergy to Benzyl Alcohol in a Cutting Oil Reodorant
Mitchell-DM; Beck-MH
Contact Dermatitis, Vol. 18, No. 5, pages 301-302, 7 references
1988
A case of contact allergy due to exposure from benzyl-alcohol (100516) in a cutting oil reodorant was described. A 28 year old male metal grinder developed an itchy patchy rash on the finger webs and dorsa of his hands 2 weeks after a new cutting oil was introduced. The rash spread to the arms, face, thighs, and feet. He was kept off work and treated with systemic steroids. The rash cleared up within 2 weeks; however, 2 days after returning to work the rash recurred. He stopped work again and the rash resolved. Following the second episode the employer stopped using the new cutting oil. Patch testing with a standard series of allergens, a cutting oil series, and the patient's cutting oil yielded positive results after 96 hours for neomycin (1404042), ethylenediamine (107153), balsam-of-Peru (8007009), parabens mix, and the cutting oil. Colophony yielded an ambiguous response. Additional patch testing with colophony, the ingredients of the cutting oil, and a flavor and fragrance battery was conducted. The patient reacted positively to a number of fragrances, benzyl-alcohol, and Vanillal-S-10026 (found in the cutting oil as a reodorant). The latter compound was found to contain 80 percent benzyl-alcohol. The authors conclude that the patient's contact allergy is due to benzyl-alcohol, one of the components of the reodorant added to the cutting oil.

Acne and Folliculitis Due to Diesel Oil
Das-M; Misra-MP
Contact Dermatitis, Vol. 18, No. 2, pages 120-121, 6 references
1988
A detailed report of a case of acne and folliculitis due to prolonged contact with diesel oil was presented. The patient had handled diesel oil with his bare hands for 15 years in employment in various automobile workshops. He complained of intermittent itching and burning, with comedones and a few pustules on the arms, hands and thighs; he also claimed to have had loss of immediate memory and alternating depression and euphoria for 6 years. Dermatological examinations showed discrete comedones on both forearms and hands and on both thighs. The liver was tender, smooth and enlarged at the costal margin. The blood picture was that of microcytic hypochromic anemia. A semen examination showed absence of sperm. A skin biopsy from the forearm revealed marked fibrosis and infiltration of chronic inflammatory cells at the base of the acne lesions. Patch testing showed a reaction to diesel oil, which was interpreted as irritant. The authors conclude that this was a case of acne and folliculitis from prolonged exposure to diesel oil, associated with hepatomegaly. They further conclude that diesel oil exposure was the likely cause of the hepatitis and psychological symptoms and was possibly the cause of the azoospermia.

Occupational Asthma Due to Oil Mists
Robertson-AS; Weir-DC; Burge-PS
Thorax, Vol. 43, No. 3, pages 200-205, 19 references
1988
Cases of occupational asthma due to oil mist exposure were examined. The subjects included 25 patients exposed to oil mists at work who were referred to an occupational respiratory clinic with asthmatic symptoms; symptoms improved on days away from work. Forced expiratory volume and vital capacity were measured with a spirometer; patients recorded their own peak expiratory flow measurements every 2 hours during waking hours using a mini peak expiratory flow meter. Serial peak expiratory flow recordings indicated that 13 of the subjects had definite work related asthma, while seven had equivocal work related asthma; these subjects often produced different patterns of peak flow response during the work week. A progressive deterioration throughout the work week was the most common pattern. Six of the patients with definite work related asthma

were given bronchial challenge tests with oil from the workplace; three had asthma induced by unused soluble oil while one reacted only to used oil. Suds oil comprised the only exposure in 13 cases, five were additionally exposed to mineral oils, and one was exposed to mineral oil only. Skin prick tests were positive in eight of 16 and elevated immunoglobulin-E was noted in nine of 18 patients. The authors conclude that occupational asthma due to oil mists is common, the peak flow is heterogeneous, and the provoking agent in the oil may vary between workers.

Sensitive Determination of Urinary Vanadium as a Measure of Occupational Exposure during Cleaning of Oil Fired Boilers
White-MA; Reeves-GD; Moore-S; Chandler-HA; Holden-HJ
The Annals of Occupational Hygiene, Vol. 31, No. 3, pages 339-343, 13 references
1987
A method for monitoring occupational exposures to vanadium (7440622) was described and was applied to workers who were cleaning boilers using chipping and wire brushing techniques. Urine samples were collected daily for 3 days at the start of each day from workers involved in boiler cleaning and from unexposed comparisons. The samples were acidified with sulfuric-acid, then 30 milliliters (ml) of each sample were treated with 1ml of 5 percent aqueous ammonium-pyrrolidine-dithiocarbamate. The chelated vanadium was then extracted into 3ml of 4-methyl-2-pentanone followed by centrifugation. An aliquot of the solvent phase was analyzed by electrothermal atomic absorption spectrometry. Breathing zone vanadium concentrations were also determined. Airborne vanadium concentrations ranged from 2.3 to 18.6mg/m3, yielding 8 hour time weighted average exposures of 0.11 to 6.4mg/m3. Urine vanadium concentrations of the comparisons were below 0.4 micrograms per liter (microg/l), the detection limit for the method. Urine vanadium concentrations in the exposed workers ranged from less than 0.4 to 10.5microg/l. The urinary vanadium concentrations were well correlated with the breathing zone vanadium concentrations and the severity of the cleaning task. The authors conclude that vanadium is rapidly excreted, appearing in the urine within 24 hours after exposure, and that occupational exposure to vanadium can be monitored by analyzing urine samples at regular intervals.

Decomposition Products of Some Cutting Oils Used in Arc Welding Operations
Gagne-M
Commission de la Sante et de la Securite du Travail du Quebec, CREF, No. 84081501, 19 pages, 17 references
1984
Decomposition products of some cutting oils applied to metals during arc welding operations were studied. The following cutting oils produced by Esso Petroleum Canada were investigated: Pennex-N47, Kutwell-45, Iocut-40, and Iocut-44. These oils were essentially made up of a mixture of hydrocarbons and some additives. Information on the nature and makeup of each cutting oil was provided by the manufacturer. No information on combustion and decomposition products could be found in the literature, and the company made no mention of Iocut and Pennex oils giving off chlorinated products during combustion; sulfur-oxides were not mentioned either. Hypotheses on the behavior of paraffinic and naphthenic hydrocarbons were formulated based on analogy with some properties of similar chemicals. The author concludes that workers should be adequately protected against the harmful effects of hydrogen-chloride (7647010) and hydrogen-sulfide (7783064) produced by the combustion of cutting oils, and emphasizes that a large number of products are given off during the arc welding process. (French)

Monitoring of Urinary Genotoxicity by Workers Exposed to Cracking-Products of Mineral Oils
Myslak-ZW; Bolt-HM
Occupational and Environmental Chemical Hazards, V. Foa, E. A. Emmett, M. Maroni, and A. Colombi, Editors; Chichester, Ellis Horwood Limited, pages 432-437, 8 references
1987
The genotoxic effects of occupational exposure to mineral-oil (8012951) mists in the glass industry were investigated. Urine samples were collected from 29 male glass foundry workers, 13 smokers and 16 nonsmokers, who were occupationally exposed to mineral-oil and from 39 comparisons, 18 smokers and 21 nonsmokers. Air samples were collected from the breathing zones of the exposed

workers during an 8 hour workshift. The air and urine samples were analyzed for genotoxic activity using the SOS chromotest; metabolic activation by S9 mix was only used with samples from air filters. Direct genotoxic activity was demonstrated in the air samples from the glass foundry. However, the genotoxicity in urine from the exposed workers was not significantly different from that of the comparisons. The urine of smokers had significantly greater genotoxicity than nonsmokers, irrespective of occupational exposure to mineral oils. The authors conclude that mineral-oil mist in the glass industry is directly genotoxic, but this is not reflected in increased genotoxicity in the urine of exposed workers.

Dermatitis from Cutting Oils and Compounds
Tower-AA
Industrial Medicine, Vol. 7, No. 8, pages 515-516, 10 references
1938
Dermatitis arising from exposure to cutting oils and compounds is discussed. Dermatitis is the most prevalent occupational disease and cutting oil related dermatitis (oil dermatitis) is considered one of the major causes of industrial dermatoses. Cutting oils generally consist of mineral oil, saponifiable oils, sulfur, and paraffin. Their major function is to act as coolants in grinding and machining operations without causing rust or fouling the machine. Oil dermatitis usually starts as a comedo in the openings of hair follicles. This progresses to a macular lesion which rapidly becomes a papule. The papules are discrete, reddish, and usually occur on the forearms, backs of the hands, and anterior parts of the thighs. Although its exact pathology is not understood, oil dermatitis is considered to be a dysfunction of the pilosebaceous apparatus resulting from mechanical plugging by the oil and irritation of the sebaceous gland. Prevention is based on instructing employees on the proper cleansing of their hands and providing adequate facilities for carrying this out. The affected employee may be treated while at work unless a secondary infection develops, in which case he should be removed from exposure. Although there is no consensus on this, using protective substances such as lanolin, olive oil, and commercial pastes may be of prophylactic value. The author concludes that oil dermatitis is a nuisance, rather than a serious problem. It can be controlled fairly easily if instructions on proper skin care are given to potentially exposed workers.

Mineral Oils
Anonymous
IARC Monographs, Evaluation of the Carcinogenic Risk of Chemicals to Humans, Volume 33, World Health Organization, Lyon, June 7-14, 1983, pages 87-168, 366 references
1984
The mineral oils discussed in this monograph are primarily lubricating oils, intended to reduce friction between surfaces in relative motion. The chemical composition of lubricant base oils depends on the original crude substance and on the processes used during refining. The materials reviewed herein are generally high molecular weight paraffinic, cycloparaffinic and aromatic hydrocarbons. Substances added to the refinery stream during manufacture of the various oil fractions include antioxidants, antirust agents, metal deactivators, antiwear and extreme pressure additives, detergents and dispersants, and biocides. Carcinogenicity studies for mineral oils which are reviewed include oral administration to rats; skin applications to mice, rabbits and monkeys; inhalation studies using mice, and rats; subcutaneous and/or intramuscular administration to mice and rats; and intraperitoneal administration to mice, and rats. Other relevant biological data include toxic effects in rats, guinea pigs, and mice; effects on reproduction and prenatal toxicity; absorption, distribution, excretion and metabolism studies; and mutagenicity testing of vacuum distillates, hydrotreated oils, white oils, steel hardening oils, and crankcase oils. Epidemiological studies in metal workers, printing pressmen, jute workers, and oil refinery workers exposed to mineral oils are described. The monograph states that there is sufficient evidence to conclude that mineral oils used in mulespinning, metal machining and jute processing are carcinogenic to humans. The evaluation also concluded that there is sufficient evidence for the carcinogenicity in experimental animals of untreated vacuum distillates, acid treated oils, aromatic oils, mildly solvent refined oils, and mildly hydrotreated oils.

Survey of Polynuclear Aromatic Compounds in Oil Refining Areas
Karlesky-DL; Ramelow-G; Ueno-Y; Warner-IM; Ho-C-N
Environmental Pollution, Vol. 43, No. 3, pages 195-207, 17 references
1987
Air samples collected in and around two oil refineries were analyzed for polynuclear aromatic (PNA) compounds using gas chromatographic mass spectrometry. Air sampling was performed in and around two oil refineries in the east Texas area on three separate occasions over a 3 year period. A high volume air sampler with a constant flow controller was used to collect particulate matter on glass fiber filters. Gas chromatography mass spectrometry was used for analysis of solvent extracts of the filters for specific PNA compounds. The concentrations and numbers of PNA compounds varied markedly between sampling times. The concentrations of PNA pollutants, particularly benzo(a)pyrene (50328), pyrene (129000), and phenanthrene (85018) were found to be much higher at one refinery than at the other. The concentration and number of PNA pollutants detected were consistently higher within the refineries than at sites some distance away. The authors conclude that more frequent and exhaustive samplings are needed to answer questions relating to longterm exposure to polynuclear aromatic compounds.

Sampling and Analytical Methods for Determining Oil Mist Concentrations
Menichini-E
The Annals of Occupational Hygiene, Vol. 30, No. 3, pages 335-348, 22 references
1986
The objective of this study was to assess commonly used sampling and analytical methods for determination of oil mist concentrations. Aerosols from fifteen lubricating oils of mineral, synthetic, and vegetable origin were collected on binder free glass fiber (GF) or on mixed cellulose ester (MCE) filters. The efficiency of both filters was about the same, however, GF filters were capable of collecting high levels of oils before migration occurred through the filter, and were therefore preferred. GF filters were resistant to solvent wash, and MCE lost weight when washed with carbon-tetrachloride, petroleum-ether, cyclohexane, or chloroform. The errors in filter weighing were small with GF filters; water adsorption on MCE filters could contribute to an appreciable error. No important sample loss occurred when filter samples were stored up to 2 weeks. Weighing of filters or extracted oil after evaporation of the solvent gave satisfactory results. Petroleum-ether boiling between 40 and 70 degrees-C was found the most suitable extraction solvent method. Recoveries were in the 95 to 99 percent range, with the exception of two oils. The detection limit in infrared and ultraviolet spectroscopic determination was in the 1 to 5 micrograms/milliliter (microg/ml) range. The fluorescence detection limit was 0.1microg/ml, however, at less than 1microg/ml, the reproducibility was poor. The mean oil mist exposure levels at seven work sites were 3mg/m3.

Changes in Water Vapor Loss from the Skin of Metal Industry Workers Monitored During Exposure to Oils
Coenraads-P-J; Lee-J; Pinnagoda-J
Scandinavian Journal of Work, Environment and Health, Vol. 12, No. 5, pages 494-498, 17 references
1986
A study was performed to determine whether there is an increase in the level of transepidermal water loss in parallel with stratum corneum damage in persons at risk of developing irritant contact dermatitis and to determine to what extent occupational exposure to oils affects skin vapor loss (SVL) levels over time. Newly recruited (previously unexposed) workers for the metal parts production departments in a Singapore plant were studied between September 1984 and May 1985. SVL measurements were made weekly for 12 weeks for three groups of workers: 17 unexposed workers, 13 workers exposed to water soluble oils and 24 workers exposed to straight mineral-oil (8012951). Four workers developed occupational dermatitis, and their SVL values were, on the average, markedly higher than those of the workers without dermatitis. Of the remaining 50 workers, baseline SVL values were comparable, but began to diverge from the second week on. The mineral oil exposed group had significantly higher SVL means on the extensor and volar sides of the forearm than the unexposed group; no significant differences were observed for the back of the hand. Means for the water soluble oils exposed group and the unexposed group were not

significantly different at most measurement times. Second degree polynomial regression equations were obtained by the least squares method. The confounding variables age, sex, and ethnicity were taken into account. An increase in SVL over time, which was attributed to exposure to oils, was demonstrated. The authors conclude that SVL measurements, at least on a group basis, could be used to detect the effect of chemical exposure on clinically normal skin. SVL readings could be used to monitor exposed workers at risk of occupational contact dermatitis.

A Case-Control Study of Leukemia at an Oil Refinery
Austin-H; Cole-P; McCraw-DS
Journal of Occupational Medicine, Vol. 28, No. 11, pages 1169-1173, 4 references
1986
Prompted by the results of an earlier study which revealed a higher than expected leukemia mortality among white males employed at an oil refinery, a case control study was carried out to establish whether a relationship existed between leukemia and work at specific job departments or exposure to benzene (71432). The 14 leukemia cases identified in the earlier study were matched with four controls each, selected among men who were employed at the same refinery for at least 6 months, as to year and age at the time of hiring and departments where they were employed, among others. Cases and controls had a 27 year average history of employment at the plant; the average age for the group was 29 years, as compared to 32 years for the myeloid leukemia group (8 cases) and 28 years for the control group. Analysis by departments, jobs performed, job and department and length and degree of exposure to benzene, failed to disclose any significant differences between the leukemia patients and the controls; statistically nonsignificant trends were identified for employment in the engineering department for all leukemia and for acute myeloid leukemia. The authors conclude that the results of the present study failed to project a distinct picture regarding the excess leukemia mortality among refinery workers, and that the population sample studied was too small which renders the findings even more difficult to interpret.

Contact Allergy to the Cutting Oil Preservatives Bioban CS-1246 and P-1487
Dahlquist-I
Contact Dermatitis, Vol. 10, No. 1, page 46
1984
Two cases of occupational contact allergy to antimicrobial agents used as preservative agents in cutting oil were described. A 45 year old woman grinder with a history of 8 years of exposure to cutting oil developed an eczematous condition on the back of the hands, which cleared up when the worker was removed from exposure, only to recur when she resumed work. Patch testing yielded a positive reaction to cutting oil and its antimicrobial additives Bioban-CS-1246 (5-ethyl-1-aza-3.7-dioxabicyclo-3,3,0-octane), Bioban-P-1487 (37304884) (a mixture of 4-(2-nitrobutyl)-morpholine and 4,4'-(2-ethyl-2-nitrotrimethylene)-dimorpholine), and Bioban-CS-1248 (a mixture of Bioban-CS-1246 and Bioban-P-1487). Negative reactions were obtained to 18 other substances used in oils. The second case, a 44 year old foreman with a 14 year history of constant contact with cutting oils, had eczema of the fingers for 4 years. The condition cleared up during vacations, only to resume upon the resumption of work. Positive reactions were recorded to formaldehyde (50000), thiuram (137268) and and two formaldehyde releasers, Grotan-BK and Grotan-OD, which were present in some of the cutting oils used by the man. Positive reactions were also obtained to Bioban-CS-1248 and Bioban-Cs-1246, but the presence of these agents in cutting oil was not certain. All three preservative agents showed the presence of formaldehyde on testing, and the author suggests that the second patient is sensitive to formaldehyde, while the first is sensitive to the preservative compounds or contaminants, since she had a negative skin test to formaldehyde.

Oil Sands Recovery-An Industrial Hygiene and Toxicology Overview
Haas-JM
Hazardous Materials Management Journal, pages 40-42
1980
Health hazards associated with the processing of oil sand hydrocarbons are reviewed. Two potential sources of hazardous exposure are described: particulate dusts in the oil sands, and a naphtha like solvent used for secondary extraction. Dust sampling methods are discussed along

with sampling results. The results of mutagenicity testing in vitro and animal toxicity studies with the solvent are reviewed; all tests were negative. The authors note that the solvent is similar to naphthas that are derived from petroleum oil.

Industrial Oil Vapors in the Etiology of Bronchopulmonary Cancer
Huguenin-R; Fauvet-J; Bourdin-J
Bulletin Societe Medicale, Vol. 65, pages 1020-1022
1949
The incidence of bronchopulmonary cancer among workers exposed to oil vapors was evaluated. Case histories of three patients with bronchial epitheliomas revealed that each had been exposed to warm machine oil vapors. Of 112 patients hospitalized with bronchopulmonary cancer, 32 had histories of repeated and prolonged contact with oil vapors; most of these were metallurgists. The authors conclude that there is an abnormally high incidence of bronchopulmonary cancer among workers exposed to oil vapors. They note that further studies may aid in defining appropriate protective measures. (French).

Prevention of Suppurative Diseases When the Hands are Contaminated with Lubricating Oils, Soot, Carbon Black or Coal Dust
Zmeyeva-LP; Zadorozhnyy-VV; Sizova-KV
Klinicheskaya Khirurgiya, Vol. 12, pages 56-57
1976
A wood soap mixture was developed for use by worker exposed to lubricating oils, soot, carbon-black (1333864) and coal dust in locomotive and passenger car depots. A large number of microtraumas complicated by suppurative diseases were found among 10,000 workers examined. Small lesions were treated with Kutnovskiy liquid which prevented infection and helped in the healing process. In comparative tests between the cedar sawdust and soap solution and regular soap and warm water, the incidence of pyogenic cocci was lower in workers who washed with the cedar sawdust and soap. The authors conclude that the alkalis in the wood soap facilitate dissolution of lubricating oils. (Russian).

Allergic Contact Dermatitis from Dipentene in Honing Oil
Rycroft-RJG
Contact Dermatitis, Vol. 6, No. 5, pages 325-329, 6 references
1980
Three case studies of contact dermatitis arising from occupational exposure to honing-oil were described. The first patient, a honing machinist, developed patches of erythema on the fingers and wrists, with scaling on the finger webs after 4 years of employment. A gear finisher, working on a honing machine once every few weeks, had mild peeling and splitting of the skin on his finger webs and the back of the fingers. After 2 years, the finger webs became vesicular, ruptured and the vesicular eruption spread to his palms. In the third patient, erythema and fissuring on the finger tips, backs of fingers and thenar eminences developed after 5 years of employment as a fitter in a machine company. All workers used machines where honing-oil flowed over the fingers and back of the hand of the operator. All three subjects had positive patch tests for undiluted honing-oil. The first and third patients also were positive for paraphenylenediamine (106503), the second was positive for turpentine, and the first and second were positive for dipentene (138863). Continued avoidance of the honing-oil eased or cleared the dermatitis. Manufacturers of the honing-oil eliminated dipentene and replaced it with an industrial alternative.

Hazard Evaluation and Technical Assistance Report No. M-TA-78-101-109, Occidental Oil Shale, Incorporated, Logan Wash, Colorado
Vegella-TJ
Mining Health Hazard Evaluations, Environmental Investigations Branch, NIOSH, Morgantown, West Virgina, 22 pages, 12 references
1980
An environmental and personnel survey was conducted on September 6 and 7, 1979 at the Occidental Oil Shale, Incorporated Oil Shale Mine in Logan Wash, Colorado. Concentrations of lead (7439921), cadmium (7440439), beryllium (7440417), benzo(a)pyrene (50328), chrysene (218019), pyrene (129000) and benz(a)anthracene (56553) were below detectable limits. Traces of methylfuran (534225), phenol (108952), strontium (7440246), benzene (71432) and fluoranthene (206440) were found. None of the carbon-dioxide (124389) samples exceeded the evaluation criteria. Personal exposures to benzene were below the evaluation criteria but benzene concentrations were above the evaluation criteria in the production mine return airways. Some workers complained of headaches and irritation of the finger tips. The author suggests various environmental controls, and recommends that regular medical examinations be provided for the workers.

Forcide 78 - Another Formaldehyde Releaser in a Coolant Oil
Hamann-K
Contact Dermatitis, Vol. 6, No. 6, page 446-, 3 references
A case of dermatitis due to presence of formaldehyde (50000) in cutting oil is described. A 25 year old engine fitter had suffered from hand eczema for 5 years. Patch testing revealed questionable sensitivity to formaldehyde. The oil company subsequently changed the preservative in the cutting oil from Parmetol-K50 to Forcide-78. The fitter also was sensitive to Forcide-78. The author concludes that the patient had been sensitized to Parmetol-K50 and the switch to Forcide-78 caused the chronicity of the eczema. He suggests that Forcide-78 be added to the list of formaldehyde releasers.

The Hazard of Occupational Poisoning by Vanadium in Cleaning Power Plant Boilers Operated on Fuel Oil - Problems in Prevention
Roshchin-IV
Gigiena Truda i Professional'nye Zabolevaniya, Vol. 6, No. 5, pages 17-22, 8 references
1962
Hazards of occupational vanadium (7440622) exposure from cleaning boilers of power producing installations (SIC-3621) operated on fuel oil were studied in the Soviet Union. The workplace air where dusty operations were performed in seven large installations using fuel oils containing sulfur had a high concentration of vanadium in the form of pentoxide and lower oxides. Lower concentrations of sulfur-dioxide (7446095) and sulfuric-acid (7664939) were found. Workers were exposed to dust for 1.5 to 2.5 hours per day and were provided with helmet respirators. Of 55 boiler cleaners examined for chronic effects, 46 had upper respiratory occupational diseases, and the incidence of these diseases increased with years of service. Twenty five percent of the workers had chronic dermatitis on the hands or eczema. The author concludes that atmospheric vanadium, sulfur-dioxide, and sulfuric-acid can cause chronic irritation of the respiratory tract and skin disorders. He recommends technological, sanitary and hygienic, and medical and prophylactic measures to prevent adverse occupational effects caused by these compounds. (Russian).

Health Risks During Cleaning of Oil-Fired Boilers Due to Vanadium and Sulfuric Acid in the Soot
Fallentin-B; Frost-J
Nordisk Hygienisk Tidskrift, Vol. 3, pages 58-72, 17 references
1954
The presence of sulfuric-acid (7664939) and vanadium (7440622) (V) in the soot generated during the cleaning of oil fired boilers was investigated. The analytical methods included polarography and colorimetry. Heavy fuel oil soot contained about 10 to 15 percent V, 30 to 40 percent sulfate, and had a pH of about 2. Light fuel oil soot contained 1 to 4 percent V, 30 to 49 percent sulfate and

had a pH of 2.5 to 4.0. No V was detected in the soot of solid fuel, but the sulfate content was 2 to 9 percent and the pH was between 4.4 and 9.2. The authors conclude that V and sulfuric acid pose a definite health hazard under these conditions, and they recommend the use of protective clothing and adequate ventilation for workers exposed to oil fire soot. (Swedish).

Health Hazard Evaluation Report, No. HETA-81-031-1209 Gulf Oil Corporation, Belle Chasse, Louisiana
Markel-HL; Slovin-DL
Hazard Evaluations and Technical Assistance Branch, NIOSH, Cincinnati, Ohio, 12 pages, 5 references
1982
Worker exposures to phenol (108952) and hydrogen-fluoride (7664393) were investigated on January 22, 1981 at the Gulf Oil Corporation Alliance Refinery (SIC-2865) in Belle Chase, Louisiana. The survey was requested by an employee on behalf of about 24 exposed workers. Earlier air sample test results were reviewed along with the OSHA Illness/Injury log, and workers were given directed medical questionnaires. Reported workplace concentration of phenol and hydrogen-fluoride were well below the NIOSH 15 minute ceiling standards of 20 and 2.5 milligrams per cubic meter, respectively. Occasional eye irritation, sometimes accompanied by cough and nasal irritation, was reported by 83 percent of the workers. These symptoms were associated with the release of hydrogen-fluoride from the alkylation unit. No other frequent symptoms were reported. The authors conclude that no exposure hazard exists at the refinery. They recommend the use of alarm systems, protective equipment, and employee training.

Occupational Health Case Report-No. 5. Cutting Oil Mists
Ramos-H
Journal of Occupational Medicine, Vol. 16, No. 4, pages 273-275
1974
The dermatological effects of cutting oils were investigated in a tool manufacturing company (SIC-3546). An environmental evaluation was performed by a NIOSH investigation team. Samples of soap and cutting oils were obtained and analyzed for pH and acid milliequivalent needed for neutralization (the amount of acid required to reduce the pH to 7). Medical evaluations were performed on the skin of 41 workers. Of the workers, 11 had dermatitis and 10 reported similar problems in the past. Oil folliculitis and primary irritant dermatitis were found to be caused by two of the cutting oils used. The pH of the soap used was 9.4, with an acid milliequivalent of 20.4. Of the two offending cutting oil compounds, the pH of compound 3 was 8.7, and 8.6 in diluted form with 1.1 and 3.2 acid milliequivalents needed for neutralization, respectively. Compound 7 cutting oil was neutral. The author concludes that gloves, aprons, and protective clothing should be worn, surfaces should be kept free of oil, and waterless hand cleaners should be used. Irritating oils should be replaced with less toxic ones, and medical treatment should be sought if dermatitis occurs.

Polycyclic Aromatic Hydrocarbons in Mineral Oil, Tar, and Pitch, Excluding Petroleum Pitch
Kipling-MD; Waldron-HA
Preventive Medicine, Vol. 5, No. 2, pages 262-278, 111 references
1976
The carcinogenicity of polycyclic aromatic hydrocarbons (PAH) contained in mineral-oil (8012951), tar (8007452), and pitch (61789604) is reviewed. A historical review of PAH as occupational carcinogens is given. The extraction and identification of PAH in soot, pitch, tar, and mineral-oil is described. The chemical structures of several PAH in tar and mineral-oil are illustrated. Methods of reducing the carcinogenicity of mineral-oil are briefly presented. The mechanism of PAH carcinogenicity is reviewed. Cancers caused by occupational exposure to pitch, tar, and mineral-oil are discussed with particular focus on scrotal cancer and oil exposure in Birmingham, England. The incidence of scrotal cancer is listed by occupation. A significant incidence of second primary tumors of the larynx, bronchus, and skin are noted. Preventive measures to avoid exposures to PAH are reviewed. The authors conclude that cancer prevention requires cooperation between exposed personnel and health and safety workers.

Epidemiological Inquiry into Cancer from Lathe Lubrication Oil
Thony-C; Thony-J
Sixteenth International Congress of Health, pages 655-656
1969
The causes and characteristics of cancer due to lathe lubrication oil exposure were investigated in the French Alps. The working conditions and practices in the French lathe turning industry were surveyed, clinical and work history data was reviewed for 97 male lathe industry workers who developed cancer, and the incidence of skin lesions was surveyed among 2152 oil exposed lathe workers. Lathe operators were the most heavily exposed group. Skin contact with the lubricating oil occurred by projection or vaporization. Exposures were most intense in small workshops with poor hygienic controls. The oils were composed primarily of petrol derivatives. Most of the 97 workers with documented cancer were craftsmen. The average age was 55 years, and the average duration of exposure was 23 years. The lesions affected the scrotum in 65 percent of the cases and the forearms in 30 percent. In about 50 percent of the cases, the lesions were spinocellular cancers accompanied by ganglion injury. The mortality rate was about 25 percent. Of the 2152 workers examined, 645 had skin lesions. These lesions appeared as varicoses, oil acne, papillomas, keratoacanthomas, or spinocellular epitheliomas. The most common sites for the lesions were the forearms, scrotum, and face. The incidence of scrotal lesions increased as the degree of malignancy increased. Combined exposure to the oils along with petrol and trichloroethylene (79016) increased the frequency of skin lesions. Duration of exposure was more important than age for the appearance of precancerous lesions. Lesion frequency was greater in individuals with poor skin hygiene and in those with dark hair. (French)

External Respiration and Gas Exchange in Workers who are Exposed to the Effect of Lubricating Oil Aerosols
Bruskin-ZZ; Demchenko-VG
Gigiena Truda i Professional'nykh Zabolevaniia, Vol. 3, No. 4, pages 28-30, 12 references
1975
The effect of exposure to lubricating oil aerosols on pulmonary function was investigated. External respiration and gas exchange functions were measured for 77 individuals, including machine tool operators exposed to lubricating oils and unexposed comparison subjects. The average values of vital capacity of the lungs (VCL) to (PVCL) were 90 percent for the exposed workers with less than 10 years of service. 74 percent for exposed workers with more than 10 years of service, and 88 percent for the comparison subjects. The 1 second forced VCL in relation to PVCL was 68, 43.3, and 64.5 percent in workers with less than 10 years of service, workers with more than 10 years of service, and comparison subjects, respectively. The tendency for reduced VCL/PVCL was greatest in females with a long service record. The maximum ventilation of the lungs tended to increase with initial exposure to the oils, then decrease as the duration of exposure increased. Oxygen consumption and its utilization coefficient increased with duration of exposure. Blood catalase activity increased with duration of exposure, peaking at 9 to 10 years then decreasing slightly. The authors conclude that chronic exposure to lubricating oil aerosols alters the functional state of the respiratory system. These changes are associated with length of employment. Exposed workers should receive periodic examinations, including chest X-rays, respiratory function tests, and blood catalase tests. (Russian)

Soots, Tars, And Oils As Causes Of Occupational Cancer
Kipling-MD
American Chemical Society Monographs. Vol. 173, Issue Chemical Carcinogens, pages 315-323, 54 references
1976
Occupational cancer resulting from exposure to soots, tars, and oils is reviewed. Several studies indicating carcinogenic effects of soot, tar, and oil are mentioned. The carcinogenicity of shale-oil is discussed. Petroleum oils and related compounds such as benzo(a)pyrene (50328), and tetramethylnaphthalene (28652746), are considered. Research with petroleum oils did not identify any single highly potent carcinogen. However, several compounds are structurally similar to very

potent carcinogens, and the total activities of the oils could result from the combined effect of several weak carcinogens. Domestic chimney soot is not a significant health risk, but exposure to carbon-black (1333864) occurs among rubber and paint manufacturers. No increased incidence of cancer is attributed to exposure to carbon-black. Employee exposure to pitch and tar occurs in the coal, gas, coke, and steel industries. Health problems associated with exposure to these substances, such as warts, skin cancer, and lung cancer, are discussed. Cancers resulting from exposure to lubricating and cutting oils are also examined. The effects of preventative measures and improved hygiene on the incidence and severity of skin cancer in industry are presented. The author concludes that the incidence of skin cancers increases in workers exposed to soot, tar, and oil.

Machine Oils And Nitrosamines Study For Carcinogenesis In Mice
Mulligan-LT; Williams-S; Plankenhorn-LJ; Garner-FM
Division of Biomedical and Behavioral Sciences, NIOSH, Contract No. 210-77-0136, 151 pages
1982
The effects of 11 synthetic machine cutting oils were examined in mice. Each oil was analyzed for diethanol-N-nitrosamine (1116547) by gas chromatography. Groups of Agouti-C3H/HEJ-mice received 0.05 milliliters of each oil topically twice weekly for 98 weeks. Each group consisted of 50 males and 50 females. During the treatment period, mice were observed for clinical symptoms. Gross and microscopic pathological studies were conducted at the end of the experiment. A high incidence of deaths were seen in mice given cutting oil number 4 which contained the highest measured concentration of diethanol-N-nitrosamine at 4.57 milligrams per gram. Treatment site masses were observed in all groups except controls. Nontreatment site tumors was seen in all females, located primarily in the mammary glands. Hepatocellular neoplasia was the only significant histological finding; it was seen most frequently in mice given cutting oil number 4 and cutting oil number 6. The incidence of proliferative liver lesions was higher in females than in males. The authors conclude that the materials in cutting oils 4 and 6 may be oncogenic to the liver. The authors also conclude that screening programs are necessary to measure methemoglobin concentrations in workers handling these oils.

Health Hazards In The Oil Industry
Jewett-RA
American Journal of Public Health, Vol. 24, No. 11, pages 1123-1128
1934
Health hazards to workers involved in producing, transporting, refining, and marketing industrial oil are reviewed. The one hazard common to all the major divisions of the industry is gas vapors. The effect is sudden, due to the nature of the poisons in the gases and vapors. The higher hydrocarbons methane (74828), ethane (74840), propane (74986), and butane (106978) pose a health threat as asphyxiants, irritants, and poisons. With petroleum products, the dangers of hydrogen-sulfide (7783064), carbon-dioxide (124389), carbon-monoxide (630080), and sulphur-dioxide (7446095) are to be considered. Health hazards connected with oil drilling include accident hazards from heavy machinery, exposure to bad weather, and the effect of noise on hearing and the nervous system. In the transportation division, the main hazard is exposure to fumes and vapors from storage tanks, reservoirs, railroad tank cars, holds of oil tankers, pipelines, and pumps. An additional hazard in this department is dust generated by cleaning pipes and tanks. Refinery workers are at risk from exposure to ammonia (7664417) and chlorine (7782505), tetraethyl-lead (78002), crude oil and its distillates. The only health hazard observed in the marketing division is irritation of the eyes of service station attendants and the use of trisodium-phosphate (7601549). The author concludes that the health hazards in the petroleum industry are easy to control.

Further Analysis Of Cancer Mortality Patterns Among Workers Exposed To Cutting Oil Mists
Decoufle-P
Journal of the National Cancer Institute, Vol. 61, No. 4, pages 1025-1030, 32 references
1978
Workers exposed to mists from cutting oils in machining operations were followed to determine hazards these oils might present. In the period from 1938 to 1967, 2,485 male workers with more

than 5 years of exposure to cutting oil mist were studied. A subgroup of 1,137 workers having received heavy mist exposure was identified. Mortality figures were compared with cause specific mortality rates for the United States as a whole. Mortality in general was lower for the study group than the population as a whole, reflecting the relative health of employed people. Expected cancer deaths were 132, while the observed deaths were 139. Analysis broken down for 15 specific cancer sites showed no significant differences between observed and expected deaths. After 20 years, a 2 fold risk of cancers of the stomach and large intestine was seen for workers in the heavily exposed group. Deaths from nonmalignant respiratory causes, expected to be 38.2, actually were only 24. The author concludes that mortality data may not actually reflect the prevalence of disease. However, exposure to cutting oil mist does not appear to pose an evident respiratory hazard but may be associated with gastrointestinal cancers.

Cutting Oils And Bladder Cancer
Vineis-P; Prima-SD
Scandinavian Journal of Work, Environment and Health, Vol. 9, pages 449-450, 15 references
1983
Carcinogenesis in metal machinists and turners due to exposure to cutting-oil was investigated. Early case studies showed a marked excess risk of scrotal cancer among turners and other machinists. Case referent studies conducted in the United States, England, Canada, Finland, and Italy reported relative risks for bladder cancer ranging from 1.5 to 5.0 for machinists, engineering fitters, and engineers. These ratings were based on 41 case studies, although these studies did not control for smoking habits. England also revealed higher mortality rates in areas where a concentration of precision engineering industries was present. In a cohort study of metal workers exposed to oil mist, 6 bladder cancer deaths occurred versus 5 expected. In another study, three bladder cancers were found among 11040 man years at risk. Two cases were found among 78 females exposed to an anti rust oil. The authors conclude that since aromatic amines are commonly used as antioxidants in cutting oils, machinists may have an excess risk for bladder cancer.

Epidemiological Survey Of Oil Distribution Centres In Britain
Rushton-L; Alderson-MR
British Journal of Industrial Medicine, Vol. 40, No. 3, pages 330-339, 29 references
1983
A mortality study of employees of oil distribution centers was conducted. Ninety nine percent of the male workers employed more than 1 year between 1950 and 1975 at three British oil companies were traced to determine vital status at the end of 1975. Mortality was compared with that of the male population of England and Wales overall and by disease categories. Subgroups were arranged by age, occupation, company, and years in service. Overall expected deaths were 4632 and observed deaths were 3926. Categories of disease that were not malignant in which mortality was considerably lower than expected were stroke, hypertensive diseases, bronchitis, and pneumonia. Ischemic heart disease was about equal the expected figure. There was, in this population, no evidence of the healthy worker effect. For one company there were excess mortalities among several subgroups with a pronounced excess in males under age 55 with 15 to 19 years in service. Overall deaths from neoplasms were less, at 1002, than the expected of 1157. Deaths from lung cancer, 384, were considerably less than the anticipated, 483. Mortality from myelofibrosis and diseases of the lymphatic and hematopoietic systems were slightly increased overall. The observed 5 myelofibrosis deaths were much greater than the 1 expected, but the number of deaths was from a very small sample size.

Cancer Mortality Patterns By Work Category In Three Texas Oil Refineries
Thomas-TL; Waxweiler-RJ; Crandall-MS; White-DW; Moure-Eraso-R; Fraumeni-JF
American Journal of Industrial Medicine, Vol. 6, No. 1, pages 3-16, 29 references
1984
Work histories of oil refinery employees and whether deaths from brain tumor, stomach, cancer, and leukemia were associated with particular work situations were examined. Records of 2132 deceased workers showed 37 deaths from brain tumor, 52 from stomach cancer, and 32 from

leukemia. From records of work history, each subject was classified according to one of the following work situations: crude oil refining, lubricating oil refining (second step refining), treating processes, coking, grease production, utilities, maintenance and labor, receipt and movement, laboratory, motor transport, and other activities. A slight association was seen for leukemia risk among workers in the treating processes category, and stomach cancer risk was elevated among maintenance workers and workers exposed to lubricating oils and paraffin wax processing (second step refining). No strong associations between brain tumor risk and employment within specific work categories were found. The authors conclude that no associations may have been found because of limitations of occupational categorizations, small numbers, or a true absence of elevated risk. Because the categories used were not exposure specific, workers exposed to particular chemicals may have had elevated risks of specific cancers regardless of the work categories assigned.

Long-Term Mortality Study Of Oil Refinery Workers. IV. Exposure To The Lubricating-Dewaxing Process
Wen-CP; Tsai-SP; Weiss-NS; Gibson-RL; Wong-O; McClellan-WA
Journal of the National Cancer Institute, Vol. 74, No. 1, pages 11-18, 22 references
1985
Mortality was studied among workers employed in the lubricating/dewaxing process of oil refining (SIC-2911). The study cohort included all male workers employed in the lubricating and dewaxing process between June 1935 and January 1978. Age, length of employment, work history and cause of death was determined for each of 1,008 male workers in this cohort. United States national age, sex and cause specific mortality rates were used to derive expected deaths for the calculation of standard mortality ratios. Solvents to which workers were exposed were identified. Area and personal samples available were compared with OSHA standards to the extent possible. The standardized mortality ratio for all causes, at 0.70, and that for cancer, 0.86, were much lower than those of the population as a whole. An increase was seen for pancreatic cancer with a standardized ratio of 1.82, but it was not statistically significant. Seven of the eight prostate cancer deaths were among non white males and almost all were among workers with experience in the entire department. Solvents to which workers were exposed included methyl-ethyl-ketone, benzene, toluene, hexane, methyl-isobutyl-ketone, and xylene. In all cases, values were far below the OSHA 8 hour standard. The authors conclude that the overall mortality patterns among these refinery workers is favorable. The relationship between prostate cancer and the lubricating/dewaxing process needs further investigation.

Occupational Asthma Due To An Emulsified Oil Mist
Hendy-MS; Beattie-BE; Burge-PS
British Journal of Industrial Medicine, Vol. 42, No. 1, pages 51-54, 11 references
1985
A case history of a tool setter with occupational asthma due to exposure from an emulsified oil mist was presented. The lubricant was a cutting oil called Superedge 4 blue used in grinding tools. The individual presented with a 10 year history of unproductive cough, wheeze, and progressive dyspnea that symptomatically improved on weekends and on holidays away from the work setting. There were changes in the big toes consistent with a diagnosis of chronic gout. Measurements of peak expiratory flow rate at 2 hour intervals revealed a deterioration in respiratory function over the course of the work day. Peak flow fell off by about 100 liters a minute during the day. In attempting to determine the cause of his asthma, initial bronchial provocation tests were made with components of the hard metals involved in the grinding operation, including cobalt (7440484) and tungsten (7440337). These substances produced no reaction. Additional tests were performed with the whole emulsified grinding oil and its components separately. The individual reacted specifically to the whole emulsified oil and to the reodorant, a pine-oil (8002093) preparation. He also reacted to colophony (8050097), a constituent of the emulsifier also derived from pine trees. In addition, the individual reacted to artist's turpentine (8006642), another pine tree product.

Cancer Risk Among Oil Refinery Workers
Savitz-DA; Moure-R
Journal of Occupational Medicine, Vol. 26, No. 9, pages 662-670, 37 references
1984
The incidence of lung cancer and other cancers among oil industry employees was assessed. In eight epidemiologic studies, population size varied from 1,015 to 55,007. Person years at risk varied from 17,546 to 575,082, reflecting a variability in duration of observation from 3 to 49 years. All studies but one relied on mortality data as the health outcome measure. No other risks for cancer, such as smoking, other occupational exposures or radiation were considered. Employment duration and latency characteristics of the work force were considered. Degree of exposure was classified by occupation. Total cancer risk assessed by standardized mortality ratio showed a consistent deficit in all analyses, with relative risks ranging from 0.76 to 0.94. Internal comparison of refinery and non refinery workers suggested a 29 percent occupational excess. Duration of exposure was examined in two studies, but neither identified an increasing risk gradient for total cancer with more prolonged exposure. The authors conclude that a more efficient approach to research is needed. Exposure, latency, and potential confounders should be examined in detail, with adequate adjustment for contributing factors.

Occupational Dermatoses From Cutting Oils
Alomar-A; Conde-Salazar-L; Romaguera-C
Contact Dermatitis, Vol. 12, No. 3, pages 129-138, 34 references
1985
Occupational dermatitis caused by various cutting oils was studied in 230 metallurgical workers. The subjects were surveyed by an extensive occupational and medical questionnaire. They were also given a series of patch tests to observe their responses to exposure to a standard series of oils and allergens. Paraphenylenediamine (106503) caused the highest percentage of positive responses, followed by potassium-dichromate (7778509), cobalt-chloride (1332827), thiuram (137268) mix, wood alcohols, formaldehyde (50000), neomycin (1404042), colophony (8050097), mercapto mix, and ethylenediamine (107153). In the oil series, 110 of 230 subjects showed a positive reaction 96 hours after application of the patch test. Benzisothiazolone (273132) gave the highest incidence of positive reactions, followed by triethanolamine (102716), hexahydrotriazine, alkanolamine vegetable fats, hexylene-glycol (107415), alkylbenzene-sulphonate (42615292), tricresyl-phosphate (1330785) and naphthenic oil. The authors conclude that a special test series of irritants should be used to test metallurgy workers.

Cutting Fluids, Oil, And Lubricants
Rycroft-RJG
Occupational and Industrial Dermatology. Maibach, H. I., and G. A. Gellin, Editors; Year Book Medical Publishers, Inc., Chicago, pages 233-236, 2 references
1982
Cutting fluids, oils and lubricants, and their relations to dermatitis are discussed. When hard materials such as metals are cut, so much heat is generated that a metal cutting tool can become welded to the metal being cut. Metalworking fluids are directed at the interface between the cutting tool and metal to reduce friction and conduct away the heat. There are three main types of metalworking fluids: neat oils, oil in water emulsions, and aqueous solutions. Skin exposures to neat (insoluble) oils have been known to cause oil acne or folliculitis, and when prolonged, hyperpigmentation, keratoses, and cancer of the scrotum and other exposed skin. Oil in water emulsions used for metalworking are commonly called soluble oils and cause primarily eczematous dermatitis. Aqueous oils also cause predominantly eczematous dermatitis. Eczematous dermatitis prevalence as high as 30 percent has occurred in machinists heavily exposed to either type of water based metalworking fluid. The clinical symptoms of soluble oil dermatitis are described. Preventive measures for soluble oil dermatitis are discussed. These are focused in three directions: nature of the machinery, oil composition, and characteristics of the worker.

Dermatitis From Paints And Oil Of Turpentine
Pirila-V
Occupational and Industrial Dermatology, Maibach, H. I., and G. A. Gellin, Editors; Year Book Medical Publishers, Inc., Chicago, pages 333-337, 6 references
1982
Agents causing occupational dermatoses among painters and those doing related work are reviewed. A study done in 1947 showed occupational dermatitis in 3.5 percent of painters and a study performed in 1978 showed a similar figure. However, although the risk has not altered, the predominant causes have. The earlier study showed the main causes of allergic dermatitis to be oil of turpentine, while a later study is reported to show oil of turpentine no longer responsible for many cases while other agents such as synthetic resins are now implicated as causative agents. Other causes of occupational dermatitis among painters such as chromates, cobalt, and colophony, are responsible for only a few current cases. A new causative agent, chloracetamide (79072), affects wallpaper hangers, as it is used in glues. It is suggested that patients be tested with their own environmental substances, not only from the working environment, but also from home and hobby areas. The desirability of a painters test battery of allergenic substances is discussed. It is suggested that painters should be tested with an extended standard test series that includes chloracetamide, phenolformaldehyde (9003354), resin, p-tert-butylphenolformaldehyde resin, and oil of turpentine. Dermatitis from rubber gloves and epoxy resins should also be suspected.

A Preliminary Report: Investigation For Shalosis Among Oil Shale Workers
Wright-WE; Rom-WN
Health Implications of New Energy Technologies, Rom, W. N., and V. E. Archer, Editors; Ann Arbor Science Publishers, Inc., Michigan, pages 481-489, 4 references
1980
Chronic pulmonary effects of exposure to silica and oil shale dust were investigated in oil shale workers (SIC-1311). Former oil shale workers completed an occupational history questionnaire and were examined through radiography and spirometry. Statistical analyses compared the oil shale workers and nonexposed controls for symptoms of chronic bronchitis, prevalence of pulmonary diseases, and radiograph and spirometry results. Oil shale workers were further divided into four work categories: crusher, miner, retort operator, and refiner. About 34.9 percent of the oil shale workers exhibited symptoms of chronic bronchitis. Spirometry results indicated that 74.7 percent of the workers showed some evidence of obstructive airways disease, and 12.7 percent had moderate or severe abnormalities. While most chest radiographs were normal, 17.4 percent were classified as pneumoconiosis. None of the oil shale worker groups had statistically significant differences from the comparison group on any of the variables, and answers to the occupational history questionnaire indicated that few of the workers had worked in oil shale operations for extended periods, and that the work at the site was intermittent. The work force also had a high rate of turnover. The authors conclude that age, smoking, and other factors may account for the prevalence of chronic bronchitis among the workers and controls.

An Occupational Health Study Of Paraho Oil Shale Workers
Rudnick-J; Voelz-GL
Health Implications of New Energy Technologies, Rom, W. N., and V. E. Archer, Editors; Ann Arbor Science Publishers, Inc., Michigan, pages 491-499, 5 references
1980
The effects of oil shale on occupational health were studied in human subjects. The investigation included field surveys of the industrial hygiene programs and sampling to assess environmental hazards in the workplace. Medical examinations of the workers were performed to determine current health status and to establish a data base for prospective epidemiological studies. The installation studied employed a total of 92 workers when the medical examinations were conducted. A total of 87 employees volunteered to participate in the study. The study population was divided into three groups based on the degree of exposure to the shale oil production process. Group-1 had the greatest exposure and group-3 had the least exposure. The medical evaluations consisted of medical history, occupational history, accident history, physical examination, laboratory and X-ray examination, special studies, and epidemiological information. Results

revealed a generally healthy population with only a few serious medical problems. There was no indication of significant health problems or effects attributable to or correlated with exposure to oil shale operations. Health problems that existed were attributable to other contributing factors, such as smoking or previous mining history. Skin problems were few in number and of a benign character. Pulmonary problems were related to smoking and mining history. There was a significant number of lost time job injuries during the year prior to the study. The authors conclude that future studies should look at the sources and mechanisms of physical injuries to workers. Periodic comprehensive medical evaluations are recommended.

Cutaneous Effects Of Shale Oil
Zone-JJ
Health Implications of New Energy Technologies, Rom, W. N., and V. E. Archer, Editors; Ann Arbor Science Publishers, Inc., Michigan, pages 457-461, 17 references
1980
The dermatological effects of shale oil exposure are discussed. Hazards of shale oil processing have not been systematically studied. Carcinogenicity of components of shale oil exposure in animals is well documented. There is no evidence that shale oil itself is carcinogenic but the potential increases when shale is subjected to mechanical processing and high temperatures. Benzo(a)pyrene and non benzo(a)pyrene fractions of shale oil processing are carcinogenic. The variables which potentially influence the development of cutaneous carcinoma in exposed persons are duration of exposure and intensity of the exposure to the potential carcinogen. A high incidence of skin and scrotal cancer among shale oil workers similar to the cutaneous effect of coal tar and pitch has been observed. The effects of the sun on the development of squamous cell carcinoma among exposed workers is discussed. Influence of skin tone, age, and sex are mentioned. The clinical signs of shale oil inflammation closely resemble those of coal tar and pitch. A study of shale oil workers and coal miners is being conducted by NIOSH. The author suggests that a prospective study over a prolonged period of time is necessary to determine the health risk of shale oil miners.

Coolant Oil Dermatitis Due To Ethylenediamine
Crow-KD; Peachey-RDG; Adams-JE
Contact Dermatitis, Vol. 4, No. 6, pages 359-361, 11 references
1978
Two outbreaks of coolant oil dermatitis from ethylenediamine (107153) exposure in machine tool operators were examined. Outbreak one occurred in a firm producing a plated, high tensile steel wire. The coolant was a soluble oil used to assist the wire through the dyes. Thirteen operators with hand dermatitis were examined; 6 had intimate contact with the soluble oil and 5 were found to have strongly positive patch tests to the neat oil. The rashes consisted of a mild dermatitis in the finger clefts and on the backs of the hands and forearms; one operator also had some eczema and edema around the eyelids. The oil contained methyl-paraben (99763) and propyl-paraben (94133) and also an ethylenediamine base at a concentration of 3 percent in the undiluted oil; four subjects reacted strongly to the ethylenediamine and were negative to the methyl-paraben and propyl-paraben. Outbreak two occurred in a light engineering works that used three brands of soluble coolant; each was at a dilution of 1:30 and also used two neat oils. Twenty nine cases of possible dermatitis were investigated; 15 cases were considered to be genuine. In all cases the eruption affected the dorsal surfaces of the hands and fingers; eruptions were dry, scaly, and erythematous with a tendency to fissure. In one worker, the palms were also affected; another worker also had involvement of the forearms. Seven workers were sensitive to Panacide-CA (97234) and ethylenediamine; four of the workers were strongly sensitive to ethylenediamine as well as dichlorophene (97234). The authors suggest that ethylenediamine sensitivity should be considered as a possible cause of sensitivity to soluble coolant oil emulsions.

Experimental Approach To The Determination Of Pulmonary Carcinogenic Influences Of Shale Oil Effluents
Palekar-LD; Coffin-DL
Environmental Health Perspectives, Vol. 30, pages 171-172, 14 references
1979

A proposed project to evaluate the potential carcinogenic hazards of shale oil effluents is reviewed. Preliminary feasibility studies of the commercial extraction of liquid hydrocarbon from oil shale are being made in the United States. Potential hazards of extraction processes must be evaluated for possible threats to the health of industrial workers, miners, processors, and machine operators, as well as the general public when such products are in use. The carcinogenicity of combustion products has been studied for a number of sources and it is recognized that crude organic extracts and many component subfractions are capable of inducing or eliciting cancers. It seems clear that the combustion products of carboniferous fuels contribute to the rate of lung cancer. The contribution of shale oil combustion must be studied in this light. The Environmental Protection Agency is evaluating the potential carcinogenicity of asbestiform minerals. Retort effluents and the combustion products of shale oil will be studied in conjunction with this program in a similar model. The effluent will be evaluated as a primary carcinogen or as a cocarcinogen. Effluents will be collected on filters, and prepared for intratracheal injection into the lungs of rats. Shale oil effluents will also be evaluated in conjunction with known organic carcinogens.

Studies Of The Scottish Oil Shale Industry. Volume 3. Causes Of Death
Miller-BG; Cowie-H; Middleton-WG; Seaton-A
Institute of Occupational Medicine, Edinburgh, Scotland, 113 pages, 21 references
1985

A mortality study of oil shale workers was conducted. The cohort consisted of all persons employed in the Scottish shale oil industry between 1950 and 1962. The vital status of 6,145 male workers was established. Of these, 2,554 subjects had died. The causes of their deaths were obtained. The mortality experienced by the shale workers was compared with that of the general male population of Scotland and with various job categories within the oil shale industry. The oil shale workers generally showed a favorable mortality pattern compared to the general population. The estimated relative hazard was 0.91. Only one specific cause showed a significant hazard; skin cancer deaths occurred in 6 subjects yielding a relative hazard of 2.59. No significantly increased risk of any major fatal disease in relation to work within the industry occurred. A case control study of 212 male patients with lung cancer, matched to 220 patients with other diseases, was conducted. The patients were treated at a hospital in the oil shale area. An excess number of oil shale workers was not found among the lung cancer patient population. The authors conclude that except for skin cancer, no significant excess of major diseases, cancerous or non cancerous, occurs in oil shale workers. It is probably unnecessary to institute elaborate screening procedures for serious diseases other than skin cancer in the emerging United States oil shale industry.

A Cohort Study On Cancer Among Workers Exposed To An Antirust Oil
Jarvholm-B; Lavenius-B
Scandinavian Journal of Work, Environment, and Health, Vol. 7, No. 3, pages 179-184, 15 references
1981

The occurrence of cancer was studied among employees exposed to an anti rust oil in an engineering company in Sweden. A study was conducted because of the occurrence of three cases of cancer among the personnel of a small department handling the oil. All persons who could be located who had worked in the department between 1954 and 1957 were studied. Expected cancer rates and mortality were calculated based on age and sex specific national rates. A comparison group was drawn from employees of a packing department not using the oil. Another group was selected based on individuals allergic to N-phenyl-1-naphthylamine (90302) identified through medical treatment given for eczema. Twelve females using the anti rust oil developed cancer in the period to the present when 3.9 cases of cancer were to be expected nationally. In the comparison group and the group allergic to N-phenyl-1-naphthylamine, there were no excesses of cancer or mortality due to cancer. The 12 tumors found in employees were located in the uterus, breast, thyroid, colon, and bladder. The authors conclude that there is an increased risk of cancer among females occupationally exposed to the anti rust oil. The active agent is probably N-phenyl-1-naphthylamine or its nitroso derivative. Individuals developing sensitivity to this chemical probably had brief exposures since they became sensitized.

Epidemiologic Studies Of Scottish Oil Shale Workers: II. Lung Function In Shale Workers' Pneumoconiosis
Louw-SJ; Cowie-HA; Seaton-A
American Journal of Industrial Medicine, Vol. 9, No. 5, pages 423-432, 20 references
1986
The lung function of Scottish oil shale workers in whom simple pneumoconiosis was present was assessed. Lung function was measured in 61 former workers with pneumoconiosis and 61 case matched comparisons in terms of forced ventilatory capacity (FVC) and forced expiratory volume (FEV), residual volume (RV), total lung capacity (TLC), and their ratio (RV/TLC). The males also completed a questionnaire regarding their smoking habits and respiratory symptoms, and dustiness of the workplace. In general, the lung functions of cases were worse than those of comparisons, with lower FEV, FVC, carbon-monoxide diffusing capacity, and vital capacity. Smoking status did not affect differences in FEV, FVC, or carbon-monoxide diffusing capacity, although smokers did show greater differences in FEV/FVC vital capacity, RV, and TLC. Workplaces for the shale miners were less dusty than conditions for coal miners. The authors conclude that the presence of pneumoconiosis in shale miners and retort workers is associated with pulmonary functional abnormalities.

Epidemiologic Studies Of Scottish Oil Shale Workers: III. Causes Of Death
Miller-BG; Cowie-HA; Middleton-WG; Seaton-A
American Journal of Industrial Medicine, Vol. 9, No. 5, pages 433-446, 15 references
1986
The vital status and causes of death among 6,145 Scottish oil shale workers were assessed. Information was obtained on date of hire, duration of employment, age at death, and cause of death. A case/control study of lung cancer was also performed. Complete occupational histories were obtained for each subject. No significant excess of mortality from any disease was found in relation to any jobs within the industry. Comparisons of the mortality experience of 3,161 workers who joined the study population prior to 1953 with that of the whole Scottish population showed an excess of deaths from skin cancer, but no significant excess that was due to any other disease. Comparisons with the population of the counties in which the industry was situated showed no significant excess of deaths from any cause examined. The case/control study of lung cancer in the shale area showed no excess risk of this disease in association with work in this industry. The authors conclude that oil shale workers in Scotland may have an excess risk of skin cancer, but they do not have an excess risk for any other disease.

Epidemiologic Studies Of Scottish Oil Shale Workers: I. Prevalence Of Skin Disease And Pneumoconiosis
Seaton-A; Louw-SJ; Cowie-HA
American Journal of Industrial Medicine, Vol. 9, No. 5, pages 409-421, 16 references
1986
The incidence of skin disease and pneumoconiosis among Scottish shale oil was studied. A total of 1,664 subjects participated in the epidemiological survey of industrial employees who had worked at least 2 years in the oil shale industry. The males answered a questionnaire regarding age, full occupational history, smoking habits, and skin conditions. Chest radiographs were conducted. No excess of skin disease was found in the workers exposed to oil or dust. A low prevalence of simple pneumoconiosis was found in workers exposed to dust, while progressive massive fibrosis occurred in approximately one percent of miners and retort workers. There was also a higher overall prevalence of reported skin disease among the miners, related to an excess of warts, moles, and itchy feet. It was believed that these workers who responded to the questionnaire and participated in the study were probably slightly more healthy than the workers who did not choose to respond. The authors conclude that skin disease is not a serious hazard in the oil shale industry, while pneumoconiosis appears to be a hazard of dust exposure in mines and at retorts.