UNIVERSITI PUTRA MALAYSIA

THE CORRELATION BETWEEN INDIVIDUAL CHROMIUM AND NICKEL IN AIR SAMPLE WITH BLOOD CHROMIUM AND NICKEL AND BLOOD PRESSURE LEVEL AMONG WORKERS IN MACHINING INDUSTRY AT NILAI, NEGERI SEMBILAN

NURSYAHIDAH BINTI MOHD BASHAH

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BY

NURSYAHIDAH BINTI MOHD BASHAH

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ABSTRACT

THE CORRELATION BETWEEN INDIVIDUAL CHROMIUM AND NICKEL IN AIR SAMPLE WITH BLOOD CHROMIUM AND NICKEL AND BLOOD PRESSURE LEVEL AMONG WORKERS IN MACHINING INDUSTRY AT NILAI, NEGERI SEMBILAN.

NURSYAHIDAH BINTI MOHD BASHAH

Introduction: Metal concentration in occupational origin is a cause of concern because of its potential accumulation in the environment and in living organisms leading to long term toxic effects. Though, there are several pieces of evidences suggesting that metals might be involved in high blood pressure and hypertension. **Objective:** The purpose of this study was to determine the relationship between individual chromium and nickel concentration in air sample with blood and blood pressure level of workers in metal machining industry. **Methodology:** This cross-sectional study was conducted on 138 male workers. Self-constructed questionnaire were given and continued with blood pressure measurement. The personal air sample was carried out after 3mL blood sample has been collected and analysed using ICP-MS. Correlation test were applied to analyze the correlation of blood pressure level with presence of metal (Cr, and Ni) in blood and air sample. Multiple linear regressions was carried out in order to determine the relationship between selected variables with chromium and nickel concentration in individual air sample, in blood and workers' blood pressure level. **Result:** Chromium and nickel concentration in air mostly exceed standard which stated in USECHH, 2000. There were significant correlation between personal air chromium and blood chromium ($p=0.021$) and also between individual nickel in air and blood ($p=0.018$). There was significant relationship between BMI and SBP level ($p=0.019$), smoking status and SBP level ($p=0.023$), BMI and DBP level ($p= 0.010$) and also work duration and DBP level ($p=0.044$). There were significant relationship between blood chromium and personal air chromium ($p=0.012$) and also between blood chromium and employment years ($p=0.044$). There was significant relationship between blood nickel and personal air nickel ($p=0.024$). There was significant relationship between personal air chromium and number of machine in each section ($p<0.001$). **Conclusion:** There were statistically significant correlations between chromium and nickel in personal air and blood sample. Personal air chromium was influenced by number of machines in the work section. Blood chromium was influenced by individual air chromium and employment years while blood nickel was influenced by individual air nickel.SBP were influenced by BMI and smoking status while DBP was influenced by BMI and work duration.

Keywords: Blood pressure, Personal air sampling, chromium, nickel, blood sample

ABSTRAK

KORELASI ANTARA INDIVIDU KROMIUM DAN NIKEL DALAM UDARA DENGAN DARAH KROMIUM DAN NIKEL DAN PARAS TEKANAN DARAH DALAM KALANGAN PEKERJA INDUSTRI PERMESINAN DI NILAI, NEGERI SEMBILAN

NURSYAHIDAH BINTI MOHD BASHAH

Pengenalan: Kepekatan logam mewujudkan kebimbangan kerana berpotensi berkumpul dalam persekitaran dan organisma hidup yang boleh mengakibatkan kesan-kesan toksik dalam jangka masa panjang. Namun, terdapat beberapa bukti yang mencadangkan bahawa logam-logam berat berkemungkinan mempunyai kaitan dengan tekanan darah tinggi dan hipertensi. **Objektif:** Tujuan kajian ini adalah untuk menentukan hubungan antara kepekatan individu kromium dan nikel dalam sampel udara dengan darah dan paras tekanan darah pekerja dalam industri permesinan. **Metodologi:** Kajian keratan rentas telah dijalankan terhadap 138 orang pekerja lelaki. Borang soal selidik yang dibentuk sendiri diberikan kepada responden dan diikuti oleh pemeriksaan tekanan darah. Sampel udara peribadi dibuat selepas 3ml sampel darah dikumpulkan dan dianalisis dengan menggunakan ICP-MS. Ujian korelasi digunakan untuk menganalisis korelasi tahap tekanan darah dengan kehadiran logam (Cr dan Ni) dalam darah dan sampel udara. Model regresi linear berganda digunakan untuk menentukan hubungan antara pemboleh ubah yang terpilih dengan kepekatan kromium dan nikel dalam sampel udara individu, dalam darah dan tahap tekanan darah pekerja. **Keputusan:** Kepekatan kromium dan nikel di udara kebanyakannya melebihi standard yang dinyatakan dalam USECHH, 2000. Korelasi yang signifikan antara kromium udara individu dan kromium darah ($p=0.021$) serta antara nikel individu di udara dan darah ($p=0.018$). Hubungan yang signifikan juga antara BMI dan tahap SBP ($p=0.019$), status merokok dan tahap SBP ($p=0.023$), BMI dan tahap DBP ($p=0.010$) serta jangka masa bekerja dan aras DBP ($p=0.044$). Terdapat hubungan yang signifikan antara kromium darah dan kromium udara individu ($p=0.012$) serta kromium darah dan tahun bekerja ($p=0.044$). Hubungan yang signifikan dapat dilihat antara nikel darah dan nikel udara peribadi ($p=0.024$) serta antara kromium udara peribadi dan bilangan mesin dalam setiap bahagian ($p<0.001$). **Kesimpulan:** Terdapat korelasi yang signifikan secara statistik antara kromium dan nikel dalam sampel udara peribadi dan darah pekerja. Kromium udara individu dipengaruhi oleh bilangan mesin di tempat kerja. Kromium darah dipengaruhi oleh kromium udara individu dan tempoh pekerjaan manakala nikel darah dipengaruhi oleh nikel udara individu. SBP dipengaruhi oleh BMI dan status merokok manakala DBP dipengaruhi oleh BMI dan tempoh masa bekerja.

Kata Kunci: Tekanan darah, sampel udara individu, kromium, nikel, sampel darah

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LIST OF ABBREVIATIONS

ATSDR	Agency for Toxic Substance and Disease Registry
BMI	Body Mass Index
Cr	Chromium
DBP	Diastolic Blood pressure
EDTA	Ethylenediaminetraacetic Acid
ICP-MS	Inductively Coupled Plasma-Mass Spectrometry
MWF	Metalworking Fluids
Ni	Nickel
OSHA	Occupational Safety and Health Act
PEL	Permissible Exposure Limit
SBP	Systolic Blood Pressure
TWA	Time – weighted Average

CHAPTER 1

INTRODUCTION

1.0 Background

Machining process such as cutting, grinding, welding, milling and drilling involved removing the material from a work piece and produce quality products. The most important manufacturing process which spent more dollars is machining in order to produce each product that has been designated. Metal machining term is used when the material in the process is metallic. It can produce metal contaminant such as heavy metal and give health impact to the workers. Metal concentration in occupational origin is a cause of concern because of its potential accumulation in the environment and in living organisms leading to long term toxic effects.

Metal-working fluids (MWFs) are extensively used in the metal working industry to cool and lubricate the tool or work piece interface. They increase tool life, wash away removed metal cuttings, protect tools from corrosion, reduce friction and improve the overall finish of the work piece (Sandin and Mattsbybaltzer, 1991). Metal machining requires lubrication and dispersion of generated heat. In addition to the materials that are purposefully introduced into metalworking fluids, numerous contaminants are known to appear with use, such as bacteria, fungi, and the metabolic products of viable organisms, trace metal contaminants from the metalworking process, and 'tramp oil' (lubrication oil that has leaked from machines performing metal working-processes) (Robins *et al.*, 1997).

Metal chromium which was the chromium form that was used for making steel. Chromium (VI) and chromium (III) are used for chrome plating, dyes and pigments, leather tanning, and wood preserving (ATSDR, 2012). It is estimated that 305,000 workers in the US are exposed to chromium and chromium containing compounds in the workplace (ECO-USA, 2000). People who live near chromium waste disposal sites or chromium manufacturing and processing plants have a greater probability of exposure to elevated levels of chromium than the general population (ATSDR, 1998).

Pure nickel is a hard, silvery-white metal, which has properties that make it very desirable for combining with other metals to form mixtures called alloys. These alloys are used in making metal coins and jewellery and in industry for making items such as valves and heat exchangers but most nickel is used to make stainless steel

(ATSDR, 2005). People may be exposed to higher levels of nickel if work in industries that process or use nickel. The workers also may be exposed to nickel by breathing dust or fumes (as from welding) or by skin contact with nickel-containing metal and dust or solutions containing dissolved nickel compounds (ATSDR, 2005).

Biological markers have the potential to play an important role in assessing aggregate exposure and informing cumulative risk assessment. Biomarkers can be indicators of the body burden of a chemical, reflecting all routes of exposure, as well as inter-individual differences in absorption and metabolism. Compared to external concentrations of chemicals, biomarkers are often believed to be more directly related to potential adverse health effects. Blood and urine samples were the most widely used and accepted matrices for biomonitoring heavy metal exposure in occupational and environmental toxicology (Gil and Pla, 2001; Gil and Hernandez, 2009). Environment and occupational particulate pollutants enter humans through the inhalation route depending on the size and shape which can be confirm by air sample. Therefore, characterization and evaluation of local biomarkers might help to verify occupational respiratory disease at a subclinical stage (Quirce *et al.*, 2009).

Blood pressure is a good indicator of risk for cardiovascular disease and a parameter that relatively easy to measure even in remote field condition. Common risk factors for high blood pressure, such as sodium intake, obesity, sedentary lifestyle, stress and economic burden are being discussed thoroughly. Several studies have shown that increase in metal concentration such as lead was associated with an

increase in blood pressure. After adjusting for age, body mass index (BMI), and nutritional factors, blood lead concentration still correlated well with blood pressure (Schwartz, 1995). There was limited or absent of studies that correlate the chromium and nickel concentration in blood with blood pressure level. So these were the aim of this study which wanted to find any correlation of chromium and nickel concentration in blood sample with blood pressure level.

1.1 Problem Statement

In assessing metal contaminant exposure in the workplace, there is complex mixture of exposure generated from work process which is hard to assess the actual exposure. Working conditions at real workplaces lead to considerably heterogeneous exposure conditions (Isaxon *et al.*, 2009) with complex mixtures of emissions from different sources like welding, grinding, soldering or chemical solvents (Korczynski, 2000) which complicate the assessment of the workers' actual exposure.

Biological sampling such as taking blood becomes a constraint because reluctant of the participation from the respondent. Other biological sampling can be done by taking hair, urine, saliva, nail and bone in order to analyse heavy metal concentration in occupational exposure. Biomonitoring has become increasingly important for the establishment of occupational and environmental limits of exposure of metal ions and has contributed to reduce exposure and to prevent adverse health effects (Gil and Hernandez, 2009).

Blood pressure is a simple measurement to be conducted in the field. Blood pressure has little evidence in association with metal exposure in blood. Common risk factors for high blood pressure, such as sodium intake, obesity, sedentary lifestyle, stress and economic burden are being discussed thoroughly and become main confounder. Thus, there are several pieces of evidences suggesting that metals might be involved in high blood pressure and hypertension. In the present study, Ni was the only metal to be related to blood pressure (inversely). Similar results were seen in a study of smoker and non-smoker hypertensive patients in Pakistan when it was shown that Cd, Ni and Pb were higher in hair, blood and urine samples of both smoker and non-smoker patients than in referents, while the concentration of Zn was lower in hair and blood but higher in the urine samples of hypertensive patients (Afridi *et al.*, 2010).

1.2 Study Justification

Concentrations of contaminant in the industry are higher compared to the environment because there is more toxic compound in the composition of the particles sampled inside the industries (Almeida *et al.*, 2010). The impact of occupational disease do not often show immediately but require long term exposure until many months, years, or even decades after exposure to health hazards. Therefore, it is important to measure the concentration of metal contaminant such as chromium, and nickel which produce during metal working process as majority of

the people spend more time in the workplace (33% of the day) than in outdoor (10% of the day) (USEPA, 1989; Oliveria Fernandes *et al.*, 2009).

What sets metalworking fluid apart from almost any other category of hazardous substance is the degree and variety of contamination to which they are subjected even in normal use, and the extent and variability to which each chemical constituent is consumed or degraded according to its individual function. Contamination of metalworking fluid has always been and always will be a problem even when the tendency to use the machine-tool sump as a rubbish bin is eradicated – the influence on the safety of operators of micro-organisms, excess lubricating oil, dissolved metal complexes, particularly ion, nickel, chromium, cobalt and work-hardened metallic swarf can be neither underestimated nor easily quantified (Hodges, 1992).

Blood is used as the biological sample to evaluate the concentration of heavy metal presence in the blood when exposed to the harmful substances. Human biological monitoring has become an important tool in environmental and occupational health for the assessment of internal exposure to harmful substances and to evaluate temporal changes in populations exposed to a defined environmental contaminant (Schuhmacher *et al.*, 2002; Nunes *et al.* 2010).

Blood pressure has little evidence in association with metal exposure in blood. The present study, Ni was the only metal to be related to blood pressure (inversely) (Afridi *et al.*, 2010). This is advantages to conduct a research in order to

find the correlation between other metal exposure in blood (chromium and nickel) and blood pressure level.

1.3 Study Variables

In this study the independent variable were chromium and nickel concentration in individual air sample and blood sample while for the dependent variable was the blood pressure level among workers in machining industry.

1.4 Conceptual Framework

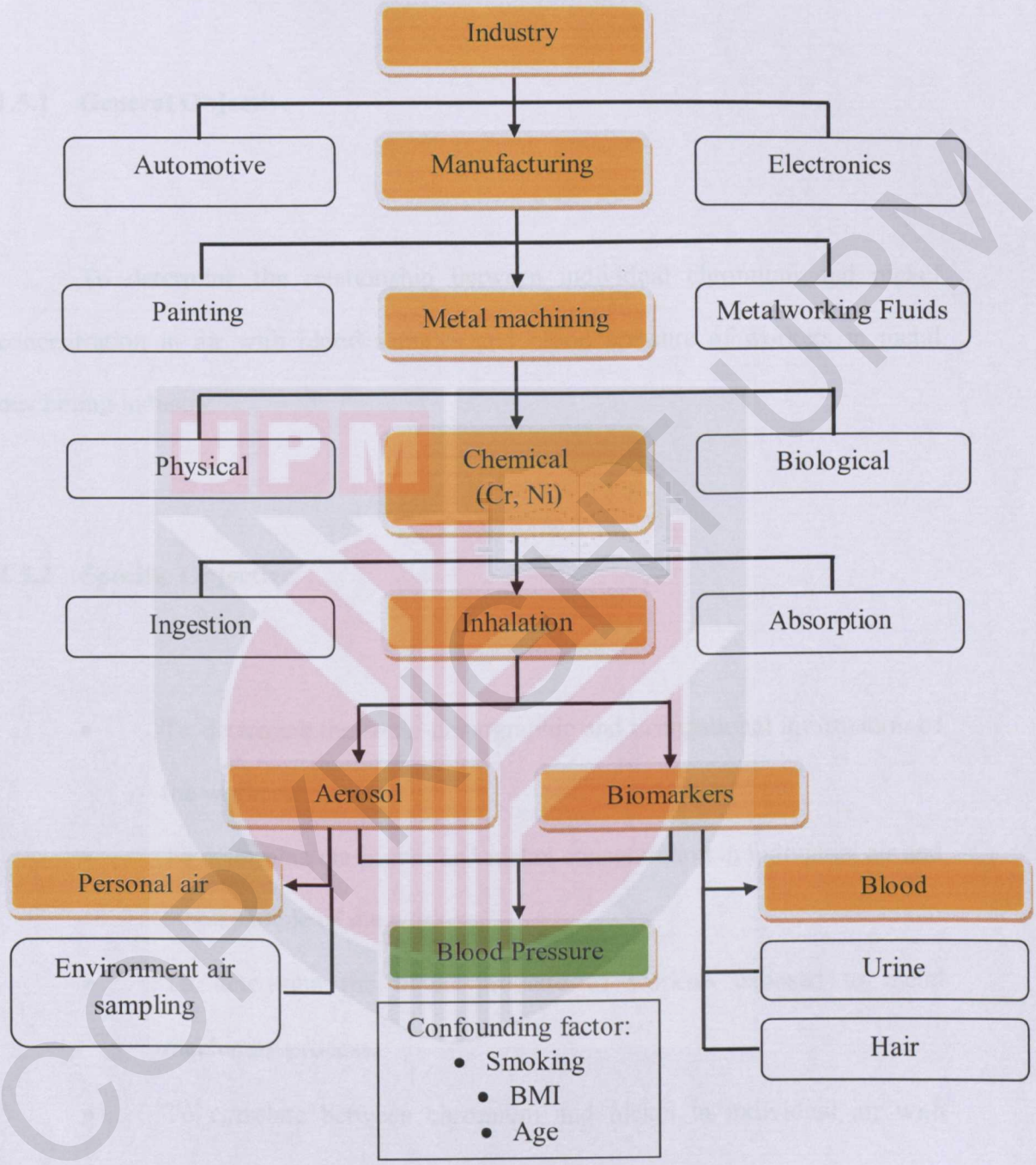

Figure 1.1: Conceptual Framework of Individual Chromium and Nickel in Air Sample with Blood Chromium and Nickel and Blood Pressure Level among Machining Industry Workers

1.5 Research Objective

1.5.1 General Objective

To determine the relationship between individual chromium and nickel concentration in air with blood samples and blood pressure of workers in metal machining industry.

1.5.2 Specific Objective

- To determine the socio-demographic and occupational information of the workers.
- To determine chromium and nickel concentration in individual air and blood sample of the workers.
- To determine the blood pressure of workers exposed to metal machining process.
- To correlate between chromium and nickel in individual air with blood sample and blood pressure of workers.
- To determine the relationship between selected variables with chromium and nickel concentration in individual air and blood samples and blood pressure of workers.

1.6 Research Hypothesis

- There were significance correlation between chromium and nickel in individual air and blood sample and blood pressure of workers in metal machining industry.
- There were significance relationships between selected variables with chromium and nickel concentration in individual air and blood sample and blood pressure of workers.

1.7 Definition of Term

1.7.1 Conceptual Definition

1.7.1.1 Machining Industry

Machining is the process of removing material from a work piece in the form of chip and divided into drilling, grinding, welding and milling process. Metal machining term is used when the material in the process is metallic which can produce metal contaminant such as heavy metal and give health impact to the workers that exposed.

1.7.1.2 Metal Exposure

Processes in machining involve drilling, grinding and milling can emit hazardous substance to the air, soil and water either is solid, liquid or gas form. Heavy metal contaminants from industry which can cause adverse effect to workers are lead, cadmium, aluminium, nickel, chromium and mercury. Among several other metals, cadmium, chromium, manganese, nickel and lead are of great significance because these elements are widely used in many areas of the metal industry including welding and alloy smelters works (Gil *et al.*, 2011).

1.7.1.3 Individual Air Sampling

Individual or personal air sampling is a method to measure the inhalable particulate that introduce into the body. Environmental and occupational particulate pollutants enter humans through inhalation route depending on the size and shape. The purpose of personal air monitoring is to identify and quantify airborne contaminants in order to determine the level of worker protection needed.

1.7.1.4 Biological Markers

A biomarker, or biological marker, generally refers to a measurable indicator of some biological state or condition. The term occasionally also refers to a

substance whose presence indicates the existence of living organisms. Biomarkers are often measured and evaluated to examine normal biological processes, pathogenic processes, or pharmacologic responses to a therapeutic intervention. Biological markers have the potential to play an important role in assessing aggregate exposure and informing cumulative risk assessment. Biomarkers can be indicators of the body burden of a chemical, reflecting all routes of exposure, as well as inter-individual differences in absorption and metabolism. Compared to external concentrations of chemicals, biomarkers are often believed to be more directly related to potential adverse health effects. Blood and urine samples are the most widely used and accepted matrices for biomonitoring heavy metal exposure in occupational and environmental toxicology (Gil and Pla, 2001; Gil and Hernandez, 2009).

1.7.1.5 Blood Pressure Level

Blood pressure is the force of blood against the walls of arteries. Blood pressure is recorded as two numbers which consist of the systolic pressure (as the heart beats) over the diastolic pressure (as the heart relaxes between beats). The measurement is written one above or before the other, with the systolic number on top and the diastolic number on the bottom. Blood pressure level determination continues to be one of the most important measurements in all of clinical medicine and is still one of the most inaccurately performed. Clinical based measurements that predict vascular disease include systolic and diastolic blood pressure (Pickering *et al.*, 2005).

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1.7.2 Operational Definition

1.7.2.1 Machining Industry

Machining industry that is selected for this research is the machining industry that involving metal working process which located at Kawasan Perindustrian Nilai, Negeri Sembilan.

1.7.2.2 Metal Exposure

Metal contaminant that being exposed by the workers in the machining industry will be collected using personal air sample and blood collection. Sample collected from the personal air sampling and blood specimen are analyse using inductively coupled plasma mass spectroscopy to determine the concentration of chromium, and nickel.

1.7.2.3 Individual Air Sampling

Individual or personal air sampling is a method to measure the inhalable particulate that introduce into the body. The instruments used to collect the particulate are cellulose ester membrane filter with 37mm diameter, cassette filter holder and personal sampling pump.

1.7.2.4 Biological Markers

Blood specimen were drawn from the arm vein of the workers by certified doctor using disposable syringes containing EDTA and samples will be transferred to EDTA tube. The tube will be stored at 4°c while waiting to be transferred to the laboratory to be analysed.

1.7.2.5 Blood Pressure Level

Blood pressure was measured using mercury sphygmomanometer by medical doctor. Each respondent had three blood pressure readings and mean of systolic blood pressure and diastolic blood pressure will be calculated using the last two readings. Blood pressure level determination continues to be one of the most important measurements in all of clinical medicine and is still one of the most inaccurately performed. The gold standard for clinical blood pressure measurement has always been readings taken by a trained health care provider using a mercury sphygmomanometer and the Korot-koff sound technique.

CHAPTER 2

LITERATURE REVIEW

2.0 Literature Review

2.1. Metal Exposure in Metal Machining Industry

Machining still remains a major industrial activity despite recent significant developments in near-net shape forming techniques. The machining system consist of cutting tool, work piece and machine tool with the cutting tool playing a major role as the cutting speed employed depend to a greater extent on the cutting tool materials. Machinists were continually exploring a cutting tool–machine tool–work piece combination which will allow rapid metal removal rate for roughing cuts with large depth of cuts at very fast speeds and will also produce required surface finishes and dimensional accuracy associated with finishing passes.

Processes in machining involve drilling, grinding and milling can emit hazardous substance to the air, soil and water either is solid, liquid or gas form. Heavy metal contaminants from industry which can cause adverse effect to workers are lead, cadmium, aluminium, nickel, chromium and mercury. Among several other metals, cadmium, chromium, manganese, nickel and lead are of great significance because these elements are widely used in many areas of the metal industry including welding and alloy smelters works (Gil *et al.*, 2011).

Among several other metals, cadmium, chromium, manganese, nickel and lead are of great significance because these elements are widely used in many areas of the metal industry including welding and alloy smelter works. Heavy metal contamination from occupational origin is a cause for concern because its potential accumulation in the environment and in living organisms leading to long term toxic effects (Gil *et al.*, 2011).

2.2. Metalworking Fluid Exposure in Metal Machining Industry

Metalworking fluids (MWFs) are generally classified into four types which are straight, soluble, synthetic and semi-synthetic oil according to the amount and type of oil they contain. They are extensively used in the metalworking industry to lubricate, cool the tool-work piece interface, and remove debris from the work surface of metal parts that are being drilled, ground, milled or turned in various metalworking operations such as cutting, grinding, and metal-forming.

Metal-working fluids (MWFs) are extensively used in the metal working industry to cool and lubricate the tool or work piece interface. They increase tool life, wash away removed metal cuttings, protect tools from corrosion, reduce friction and improve the overall finish of the work piece (Sandin and Mattsbybaltzer, 1991). Metal machining requires lubrication and dispersion of generated heat. In addition to the materials that are purposefully introduced into metalworking fluids, numerous contaminants are known to appear with use, such as bacteria, fungi, and the metabolic products of viable organisms, trace metal contaminants from the metalworking process, and 'tramp oil' (lubrication oil that has leaked from machines performing metal working-processes) (Robins *et al.*, 1997).

What sets metalworking fluid apart from almost any other category of hazardous substance is the degree and variety of contamination to which they are subjected even in normal use, and the extent and variability to which each chemical constituent is consumed or degraded according to its individual function. Contamination of metalworking fluid has always been and always will be a problem even when the tendency to use the machine-tool sump as a rubbish bin is eradicated – the influence on the safety of operators of micro-organisms, excess lubricating oil, dissolved metal complexes, particularly ion, nickel, chromium, cobalt and work-hardened metallic swarf can be neither underestimated nor easily quantified (Hodges, 1992).

2.3. Biological Markers

Biological markers have the potential to play an important role in assessing aggregate exposure and informing cumulative risk assessment. Biomarkers can be indicators of the body burden of a chemical, reflecting all routes of exposure, as well as inter-individual differences in absorption and metabolism. Compared to external concentrations of chemicals, biomarkers are often believed to be more directly related to potential adverse health effects.

Biological monitoring provides some advantages over air monitoring, giving an estimate of the exposure and an indirect approach for determining target site concentration by measurement of trace elements as biological indicators. Each sample reflects the current body burden, being a function of not only the current exposure level, but also what happened some time before, depending on the half-life of the trace elements.

Due to very low normal levels and the risk of contamination from surroundings, measurements of arsenic, cadmium, chromium, cobalt and nickel in biological materials is extremely difficult. Therefore, sensitive analytical methods are needed for the measurement of these trace elements in blood and serum (Versieck and Cornelis, 1989). Results from environmental and biological monitoring programmes are abundant, but such data are often used for exposure assessments without demonstrating the quality of data. In this context, accuracy and standard

uncertainty for the analytical method need to be considered to ensure that the performance characteristics of the methods are understood.

Blood and urine samples are the most widely used and accepted matrices for biomonitoring heavy metal exposure in occupational and environmental toxicology (Gil and Pla, 2001; Gil and Hernandez, 2009). Environmental and occupational particulate pollutants enter humans through the inhalation route depending on the size and shape. Therefore, characterization and evaluation of local biomarkers might help to verify occupational respiratory disease at a subclinical stage (Quirce *et al.* 2009).

2.4. Trace Metals in Air Sample

Trace metals in air phase can be classified as metals or metalloids including the semi-metallic elements. Both natural and anthropogenic processes and sources emit metals and their compounds into the air. The processing of minerals, incineration of metallic objects, motor vehicle combustion of fuel containing metal additives, and the wearing out of motor vehicle tyres and brake pads result in the emission of metals associated with particulate matter. Trace metals are part of a large group of air pollutants called air toxics, which upon inhalation or ingestion can be responsible for a range of health effects such as cancer, neurotoxicity, immunotoxicity, cardiotoxicity, reproductive toxicity, teratogenesis and genotoxicity (Yaman, 2012).

Occupational and environmental health exposure id usually estimated by measurement of the airborne pollutants or by biomonitoring. Several authors have reported significant correlation between airborne trace element levels and concentrations in blood and urine (Heinzow *et al.* 1991). However the extent to which airborne trace element levels reflect true external exposure is doubtful, and it may be considered that adverse health effects of these trace elements are not only related to species and total dose but also to peaks of exposure.

When inhaled, very small particles containing metals or their compounds deposit beyond the bronchial regions of the lungs into the alveoli region (Kennedy, 2007). The localized release of some heavy metals from inhaled particulate matter has been hypothesized to be responsible for the lung tissue damage. Studies in occupational or community settings have established the health effects of exposure to trace metals, such as lead, cadmium, nickel and their compounds (Rovira *et al.*, 2011). Accumulation of metals in human body can have middle and long-term health risks and can adversely affect the physiological functions. Metals can enter the human body mainly through inhalation and ingestion, with the diet being the main route of human exposure for non-occupationally exposed individuals.

In respect to their effects on the environment and on human health, gaseous forms such as organometallic compounds can be characterized by other parameters, such as water solubility, particle size distribution, morphology and specific surface

area, and chemical heterogeneity of the particles, or the concentration of metals and metalloids in the particles ultimately contacting target tissues in human body.

To evaluate and reduce the health and environmental effects of toxic metals in inhaled ambient air matrices, it is vitally important to know their chemical compositions and the way they vary in time and in space. Therefore, there are continuing efforts to determine particularly toxic metals such as Pb, Cd and Ni in air phases. In considering lead and cadmium in ambient air samples, this importance increases because the absorption rates of those metals by inhalation are significantly higher (up to 50-60%) than those by ingestion (between 3% and 10%) (10). The localized release of some heavy metals from inhaled particulate matter has been hypothesized to be responsible for the lung tissue damage.

2.5. Inductively Coupled Plasma-Mass Spectrometry

Determination of a growing number of elements in body fluids places increasing demands on clinical laboratories. In part, this demand reflects an increasing range of occupational and environmental exposures. To some extent, an increasing awareness of multielements interactions, and their potential clinical impact, under-scores the need for comprehensive analysis of human body fluids. The most common method for quantitative trace element analysis of biological materials is atomic absorption spectroscopy. Good results are obtained at relatively low cost with this method but incapable of a rapid multielement survey.

Inductively coupledplasma-mass spectrometry (ICP- MS) has emerged as a promising and versatile means of providing rapid, multielemental profiles of a wide variety of samples. This technique has been applied to serum and blood and others, with emphasis on quantitative analysis of selected elements of biological interest. These analyses at present require careful attention to matrix matching and spectral interpretation, and are improved by differential optimization of instrumental settings in selected mass ranges.

However, ICP-MS also has the capability of rapidly scanning masses across the periodic table. This is achievable because the quadrupole detector is capable of peak-hopping between mass-to-charge (miz) ratios with typical times of 20 ma and is tunable to cover a range of m/z ratios from 1 to 300. Previous study have described in detail the general three-step process of data acquisition, deconvolution, and concentration estimation involved in a semi-quantitative survey with ICP-MS (Ekiinoff *et al.*, 1989)

The manufacturer of the Elan 250 ICP-MS (Perkin-Elmer Sciex, Thornhill, Ontario, Canada) provides a software pack- age, SEMI-QUANT, which scans a user-specified range of masses and applies corrections for spectroscopic overlaps, based on a built-in table of natural abundances of the isotopes. This software should allow a comparison between a clinical sample of interest and established normal ranges, which may indicate whether further, more detailed analyses are needed.

2.6. Blood Pressure Level

Blood pressure is typically recorded as two numbers, written as a ratio of systolic and diastolic. Systolic reading is used to measure the pressure in the arteries when the heart beats while for diastolic measures the pressure in the arteries between heartbeats which means when the heart muscle is resting between beats and refilling with blood.

Blood pressure is a simple measurement to be conducted in the field. Blood pressure has little evidence in association with metal exposure in blood. Common risk factors for high blood pressure, such as sodium intake, obesity, sedentary lifestyle, stress and economic burden are being discussed thoroughly and become main confounder. There were several pieces of evidences suggesting that metals might be involved in high blood pressure and hypertension.

In the present study by Alfridi *et al.* (2010), Ni was the only metal to be related to blood pressure (inversely). Similar results were seen in a study of smoker and non-smoker hypertensive patients in Pakistan when it was shown that Cd, Ni and Pb were higher in hair, blood and urine samples of both smoker and non-smoker patients than in referents, while the concentration of Zn was lower in hair and blood but higher in the urine samples of hypertensive patients (Afridi *et al.*, 2010).

CHAPTER 3

METHODOLOGY

3.0 Methodology

3.1 Study Location

The study location for this research was conducted at metal machining industry. The machining industry was located at Nilai Industrial Estate, Negeri Sembilan where workers who fulfil the inclusive criteria and exposed to metalworking fluid in metal working process were assessed.

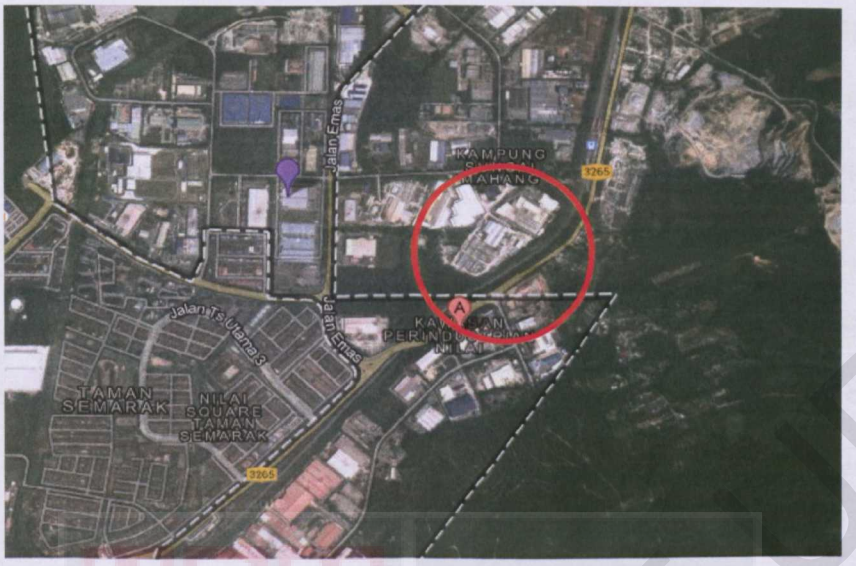


Figure 3.1: Study locations at Nilai Industrial Estate, Negeri Sembilan.

3.1.1 Factory Information

The main products produced by this factory were bearings. The purpose of a bearing was to reduce friction, most often on a rotating shaft. It was made of many different materials including sintered bronze, which holds oil to reduce friction, and various metals which were cast in place to make a soft slippery surface for really heavy shafts. A bearing can also use balls or rods between two hardened metal surfaces, the balls or rollers convert what would be a sliding contact to a rolling point contact.

Steels as raw materials were used to produce bearing which have variety of elements in total amounts between 1.0% and 50% by weight to improve its mechanical properties. The elements that were used to improve the mechanical properties of the steel in order to produce high quality of bearing were chromium, nickel, iron, molybdenum, manganese, carbon, phosphorus, sulphur and nitrogen. Based on verbal conversation with the Quality Control Officer of the factory, chromium and nickel were the highest elements that contained in the steel which made up18% of chromium and 9% of nickel by weight (Personal communication, 2014).

There were four main types of product manufactured by the studied factory which were Self-Aligning Ball Bearing (SABB), Deep Groove Ball Bearing (DGBB), Spherical Roller Bearing (SRB) and Large Size Roller (LSR). Each of the products has different shaft size and performance. The flow of the process begin with cutting, washing, heating, grinding, whitening, greasing, quality checking and packaging. The job sections were divided based on the type of product produced in that particular section. Figure 3.2 showed the plant layout of the factory for each section.

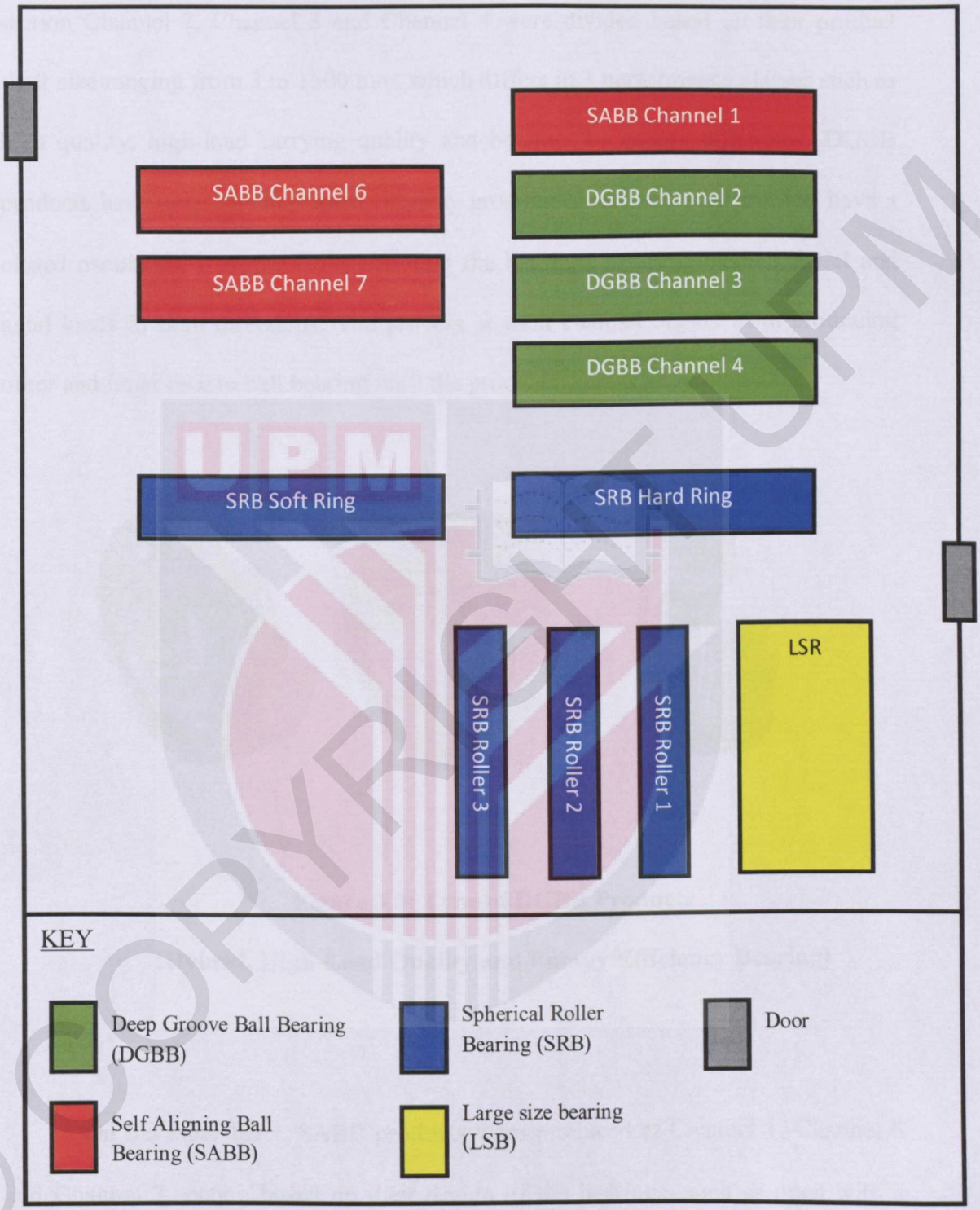


Figure 3.2: Plant Layout for Each Section and Type of Products.

Sections included in DGBB were Channel 2, Channel 3 and Channel 4. The section Channel 2, Channel 3 and Channel 4 were divided based on their product shaft size ranging from 3 to 1500 mm, which differs in 3 performance classes such as high quality, high-load carrying quality and bearing for energy efficiency. DGBB products have deep, uninterrupted raceway grooves. These raceway grooves have a closed osculation with the balls, enabling the bearings to accommodate radial and axial loads in both directions. The process at each channel begins from producing outer and inner race to ball bearing until the products were attached together.

Figure 3.3: Type of DGBB Products

(Hybrid, High-Load Quality and Energy Efficiency Bearing)

On the other hand, SABB products were produced at Channel 1, Channel 6 and Channel 7 section based on their design of the bearings, such as open with a basic design, sealed bearing with contact seals on both sides and open bearings with an extended inner ring. The bearings were consequently self-aligning and insensitive to shaft deflections and angular misalignment of the shaft relative to the housing.

Additionally, self-aligning ball bearings generate less friction than any other type of rolling bearing, which enables them to run cooler even at high speeds. The processed begins with the production of balls to rings until products attachments.

Figure 3.4: Type of SABB Products
(Open With a Basic Design, Sealed Bearing with Contact Seals on Both Sides and Open Bearings with an Extended Inner Ring)

Different from DGBB and SABB, for SRB, the sections were split into 5 sections, which were Soft Ring, Hard Ring, Roller1, Roller 2 and Roller 3. For sections SRB Soft and Hard Ring, it produced the ring of the bearing, where section SRB Soft Ring manufactured inner ring while section SRB Hard Ring manufactured the outer ring and act as assemble area for SRB products. However, in sections SRB Roller 1 until 3, the production produced the spherical bearing with different types such as open bearing, sealed bearings and bearing for energy efficiency.

Figure 3.5: Type of SRB Products

(Open, Energy Efficient and Vibratory Application Bearings)

Lastly, LSR consist only 1 section which at these section it produced various kind of bearing for accommodation of large and heavy equipment and machineries. The productions at LSR section will be done based on clients' demand to produce products in a larger size.

Figure 3.6: Products Produced by LSR Section

For every Sections of DGBB, SABB, SRB, and LSR, there were various kinds of metalworking fluids being used which resulted in different environmental exposure to workers for each division.

3.1.2 Work Process

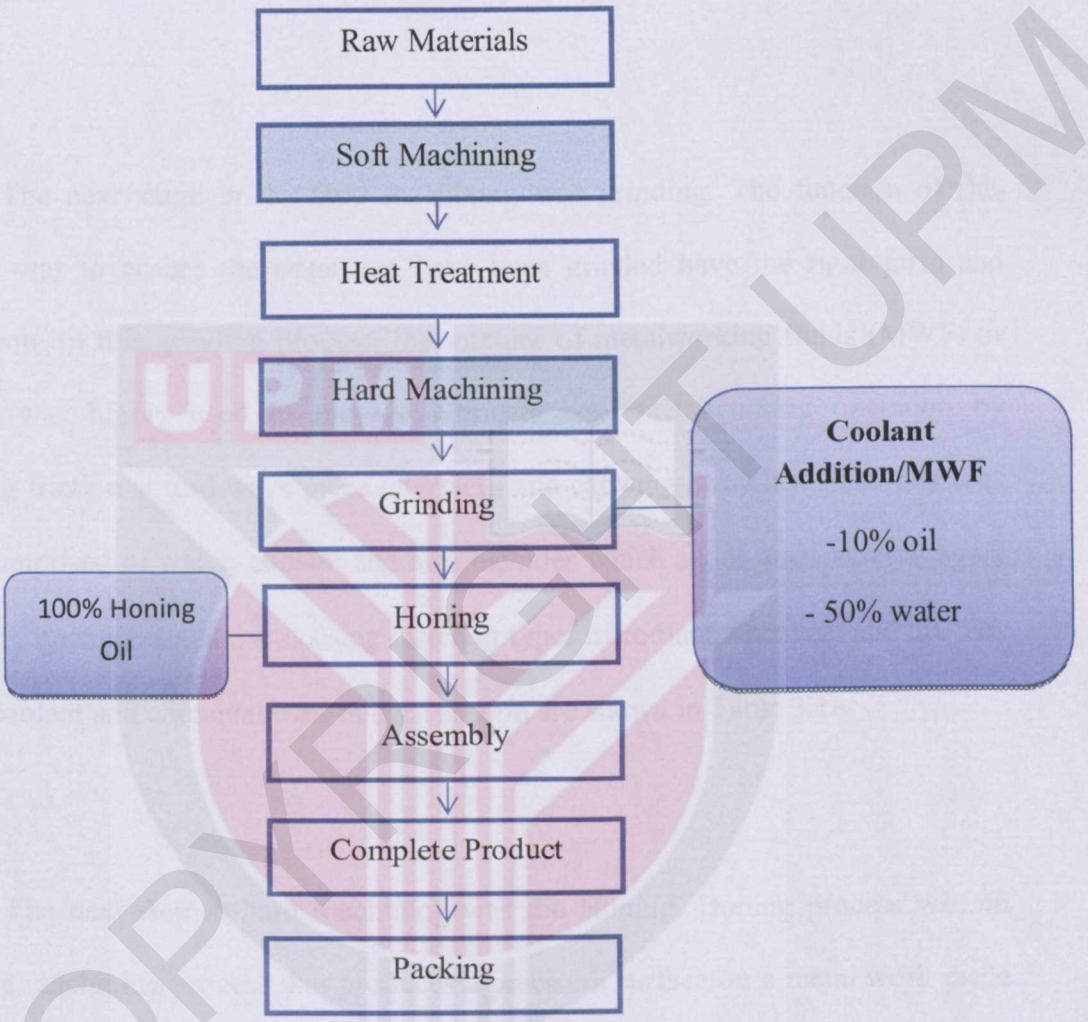


Figure 3.7: Flowchart of the work process for bearing manufacturing

Figure 3.7 above showed the flowchart of the work process for bearing manufacturing. The raw materials in bearing manufacturing are depends on the types of products. Ball bearing was commonly made of high carbon steel. In soft

machining, the hardening of the steel was achieved by a heating treating process. Hardness was a function of brittle structure. Hardening ability, which was a measure of the depth of full hardness achieved, was related to the type and amount of alloying elements.

The next stage in the hard machining was grinding. The function of this process was to ensure the rings that have been grinded have the right form and dimension. In this grinding process, the mixture of metalworking fluids (MWF) or coolant was highly used to provide lubricate cool metalworking operation by reducing friction at tool-work piece interfaces and carrying away heat. The mixtures were comprised of water, coolant and also biocides which act as anti-bacterial agent in MWF. Each job section was using different types of coolant, chemical and oil. The list of coolant and chemical used in each section are shown in Table 3.1.

The next step in hard machining was the Honing. Honing process was an abrasive machining process that produces a precision surface on a metal work piece by scrubbing an abrasive stone against it along a controlled path. Honing was primarily used to improve the geometric form of a surface, but may also improve the surface texture. In this process, honing oil was used. After the honing process, the final products were ready to be assembling before the packaging process.

Table 3.1: The list of MWF and Chemical Used in each Section

METALWORKING FLUIDS (MWFS)	WORK SECTION			
	DGBB	**SABB**	**SRB**	**LSR**
COOLANT	HYSOL X	HYSOL X	HYSOL X	HYSOL X
LUBRICANT	-	ANTICORIT 03W FF	HYSPIN AWS 68	-
CUTTING OIL	-	-	ILOCUT 603	ILOCUT 603
CLEANING AGENT	CASTROL SOLVENT D100	CASTROL SOLVENT D100	P3-NEUTRAPON 5088	CASTROL SOLVENT D100
OTHER	H 460 (BOOSTER)	H 460 (BOOSTER)	HYDRAULIC VG22 MI	H 460 (BOOSTER)
	-	-	H 460 (BOOSTER)	-
	-	-	SC 388	-
ANTI-CORROSION	BIOGARD 25	BIOGARD 25	RUSTILO DWX 88	BIOGARD 25
	KOOLGARD 16	KOOLGARD 16	-	KOOLGARD 16

***Refer the MSDS of these chemicals in Appendix**

Based on Table 3.1, in the production of different type of bearing, there were several types of Metalworking Fluids (MWFs) being used in each sub-section in the studied factory. Each type of MWFs has different function which characterised based on the their function during the product production such as coolant, cutting oil, cleaning agent, anti-corrosion and others types of MWFs.

Hysol X was type of metalworking fluids that have been used in every section. Addition of Hysol X into the machine was to reduce the heat and friction when undergoes cutting process as all raw materials received will go through cutting process to be divided into smaller portion needed by each section.

Besides the Hysol X, ANTICORIT 03W FF and Hyspin AWS 6 were also a type of MWF. ANTICORIT 03W FF was used as a lubricants for smoothen the movement of bearing when it was attached together with the ring. Usually the oil will be applied to the inner ring before attachment of ball bearing and outer ring. While for Hyspin AWS 6, it was known as machine lubricant, as it reduce friction produce during the cutting process in SRB.

ILOCUT 603 was only been used in bulk cutting for SRB and LSR division since the process of the products were different compare to DGBB and SABB. The function of the oil was to prolong the life of the tool and decrease the usage of the tool since SRB were for heavy duty applications A specialised cutting oil known as ILOCUT 603 were used when the steel were cuts into a specific shape.

Cleaning agent was widely been used in the factory and also categorised as MWFs. Castrol Solvent D100 and P3-Neutrapon 5088 were types of cleaning agent used in the factory. This two cleaning agents function was to clean and rinse off MWFs oils and water based from the products. Other than that, the Castrol Solvent D100, have another specific function was to smoothen the surfaces and edges of products from any metal pieces.

Anti-corrosion was widely been during the work process of bearing production to improve the quality of the products and also to prolong the life of the bearing. Rustilo DWX 88, Biogard 25, and Koolgard 16 were the anti-corrosion agent that has been used in the factory. Types of anti-corrosion agent used by the machine depending on the type of products based on the products criteria and suitability.

Other types of MWFs such as H 460 (Booster) was used as a polishing agent to enhance the quality of the products at the end of the all bearing production. As for Hydraulic VG22 MI, it was applied to roller before undergoes heat treatment to expand the size of the roller at SRB section and for harden the roller. And lastly, SC 388 was used as a whitening agent at SRB due to physical changes of roller after going through heat treatment.

3.2 Study Design

This was a cross-sectional study. The concentration of chromium, and nickel in blood and personal air sampling were analysed in the laboratory, while the blood pressure of the workers from exposed to metal contaminants exposure was carried out by medical doctor at the metal machining factory in Nilai Industrial Estate, Negeri Sembilan.

3.3 Study Sampling

3.3.1 Sample Population

Workers who were exposed to metal working fluid in metal machining process were comprised of different work process. Exposed workers were those who work with or near the metal machining process.

3.3.2 Sampling Frame

A name list of the factory workers which were provided by human resource department.

3.3.3 Sampling Unit

The sampling unit was the workers that meet the inclusion criteria which consist of age within 20 – 45 years, deal with or near the metal working fluid in metal machining process, and no history of health problem or disease (thyroid, diabetes and hypertension).

3.3.4 Sampling Method

Simple random sampling method was used to select the study respondents. Subjects were chosen from those who matched and fulfilled the inclusion criteria.

3.3.5 Sample size

In determining the sample size, Yamane (1967) formula had been used to calculate the sample size.

$$n = \frac{N}{1 + N\,(e)^2}$$

Where n = sample size

N = population size

e = level of precision (0.05)

The population size in this study was 154. The calculated was shown as below:

$$n = \frac{250}{1 + 250\,(0.05)^2}$$

$$= 154 \text{ respondents}$$

After considering a 10% invalid questionnaire or any missing data the final sample size estimated will be 169. Thus, the total of sample size which has been chosen in this study is 169 respondents. The calculations were as follows:

Final sample size = 10% + N

= 15 + 154

= **169 respondents**

3.4 Study Instrumentation

3.4.1 Questionnaire

The self-constructed questionnaire was used to get information from the workers. The set of questionnaires were administered to collect personal information, basic demographic information, occupational information and medical history. In

order to obtain information for respondents' BMI, height and weight were measured using digital weighing machine and body meter SECA® 208.

3.4.2 Blood Sample and ICP-MS Analyse Method

Blood sample were drawn to analyse the presence of metal contamination (Chromium and Nickel) in blood when workers exposed to metalworking fluid from metal working process. The blood samples then were analysed using inductively-coupled plasma mass spectrometry to determine the concentration of chromium and nickel in blood of the exposed workers. Inductively Coupled Plasma-Mass Spectrometry has the ability to perform multielemental analyses.

The equipments had been used to collect the blood were:

- Disposable syringes and needles
- 3mL lavender-capped BD Vacutainer® blood collection tubes containing K2EDTA anticoagulant
- Tourniquet
- Gauze
- Gloves
- 70% alcohol pad
- Ice Pack and Cool Box
- Leak-proof transportation bags and containers
- Disposable sharp bin

The instruments and equipments had been used to analyse Cr and Ni in blood:

- Inductively-coupled plasma-mass spectrometry equipped for determination of elements of interest.
- Beaker, Griffin (50-mL) or Phillips (125-mL), with watch glass covers.
- Pipettes, 5- and 10-mL
- Volumetric flasks, 5- and 10-mL and 1-L.
- 2mL Nitric Acid (HNO_3)
- 1mL Hydrogen Peroxide (H_2O_2)
- 10mL autosampler polypropylene tube

3.4.3 Personal Air Sampling and ICP-MS Analyse Method

Personal air sampling had been done individually to all selected workers that exposed to metal working process. This method was used to determine the concentration of chromium, and nickel presence in personal breathing zone using personal sampling pump. The personal air sample then were analysed using inductively-coupled plasma mass spectrometry to determine the concentration of chromium and nickel in blood of the exposed workers. Inductively Coupled Plasma-Mass Spectrometry has the ability to perform multielemental analyses which simultaneously reduce total analysis time as well as cost.

The instrument used for personal air sample:

- Cellulose ester membrane filter, 0.8µm pore size, 37mm diameter
- Cassette filter holder
- Personal sampling pump (1-4L/min)
- Flexible connecting tubing and calibration jar
- Supporting pad

The instrument used to analyse Cr and Ni in personal air sample:

- Inductively coupled plasma-mass spectrometry, equipped as specified by the manufacturer for analysis of elements of interest.
- Beaker, Griffin (50-mL) or Phillips (125-mL), with watch glass covers.
- Volumetric flasks, 5- and 10-mL and 1-L.
- Nitric acid (HNO_3), conc., ultra pure
- Perchloric acid ($HClO_4$), conc., ultra pure
- Ashing acid: 4:1 (v/v) HNO_3: $HClO_4$. Mix 4 volumes conc. HNO_3 with 1 volume conc. $HClO_4$
- Calibration stock solution, 1000µg/mL. Commercially available, or prepared per instrument manufacturer's recommendation
- Dilution acid, 4% HNO_3, 1% $HClO_4$. Add 50mL ashing acid to 600mL water; dilute to 1L
- Distilled water and deionised water

3.4.4 Blood Pressure

Blood pressure was measured to determine the level of blood pressure of the workers which is related to Cr, and Ni concentration presence in blood. The blood pressure had been measured using mercury sphygmomanometers, 15-inch stethoscopes, and cuffs sized to the subjects' arms by certified medical doctor. Each respondent had three blood pressure readings and mean of systolic blood pressure and diastolic blood pressure will be calculated using the last two readings

3.5 Data Collection Procedure

Ethical approval was obtained from the Medical research Ethic Committee, University Putra Malaysia (UPM) prior for data collection. Permission letter to conduct the research at the factory at Nilai Industrial Estate, Negeri Sembilan has been sent to the Head of Human Resource Department and had been approved to conduct the research.

3.5.1 Questionnaire

The height and weight had been conducted first in order to determine the BMI before the questionnaires were distributed to the respondents. The self-constructed questionnaire had been distributed to the exposed respondent to be filled

which have seven sections consisting of socioeconomic information, smoking history, work history, recent working information, work environment and disease history. Face to face interviews were conducted upon respondent fill up the questionnaire.

3.5.2 Blood Sample and ICP-MS Analyse Method

The written consent from respondents was obtained before the blood sampling. The blood sampling procedure and information had been explained orally, clearly precisely to the respondent before the blood sampling. Blood sample were drawn by certified doctor.

Venepuncture technique had been used for blood sample. Firstly, a good-sized vein was identified, usually in antecubital fossa or on dorsum of the hand. Tourniquet had been applied to the site of venepuncture to ensure engorgement of vein with blood, the site of venepuncture was cleaned with alcohol swab. The disposable needle had been inserted (30°) into vein and gently draws approximately 3mL blood into syringe. Cotton swab were placed over site of needle insertion and the needle were gently removed. The blood were transferred into purple EDTA tube and labeled with respondent information (name, time and date of collection). The EDTA tubes were gently inverted at least 10 times to reach a proper mix of additive and blood (do not shake). Blood sample were stored at 4°c for transportation and stored at -80°c before analysis had been carried out prior to blood sample collection (within 2 days).

Two hours before sample preparation, the blood samples were brought to room temperature. They were mixed gently for homogenisation. Accurately 0.5ml of whole blood was taking into Pyrex flask separately. To this was added 3 ml of freshly prepared mixture of concentrated nitric acid and hydrogen peroxide [HNO_3 – H_2O_2] (2:1 V/V) and stood for 10 minutes. The flasks were covered with watch glass and then digested at 60 - 70°c for 1 – 2 hours. The digests were then treated with 2 ml nitric acid and few drops of H_2O_2 while heating continued on hot plate at about 80°c until a clear digested solution was obtained.

The excess acid mixture was evaporated to semi – dry mass, cooled and diluted with 0.1ml nitric acid. These were transferred into 100ml volumetric flask and diluted to mark using triply distilled water. A blank extraction (without sample) was carried out through the complete procedure using triply distilled water. Special care was taken to avoid any contamination with metals during the blood sampling, storage, and analyses (Yahaya *et. al,* 2013). The blood chromium and nickel measurements were performed by Elan DRC II Inductively coupled plasma-mass spectrometry.

Unit measure from ICP-MS was in ppb or µg/L. In order to get the exact value of chromium and nickel present in blood, the calculation was followed as below:

C = Chromium or nickel concentration in µg/L x Dilution factor

Where,

C = concentration

*Dilution factor = 200

3.5.3 Personal Air Sampling and ICP-MS Analyse Method

Personal air sampling had been done for 8 hours within personal breathing zone of the workers that exposed to metal machining process. The workers had been explained about the purpose of the research, time taken for the sampling and remind them about do not switch off the pump while sampling still running. The sampled was sealed by gel band and transported to the laboratory for analysis.

Each personal sampling pump was calibrated with a representative sample in line. It was sampled accurately at known flow rate between 1 and 4L/min for a total sample size of 200 to 2000L for TWA measurement. The cassette filter holder was opened and transferred the samples and blanks to clean beakers. 5mL ashing acid was added and covered with a watch glass and stand for 30 min at room temperature (start reagent blank at this step). The samples were heated on hotplate (120°c) until

ca. 0.5mL remains. 2mL of ashing acid was added and the step before was repeated until the solution was clear.

The watchglass was removed and rinsed into the beaker with distilled water. The temperature was increased to 150°c and the sample was taken to near dryness (ca. 0.5mL). The residue was dissolved in 2 to 3 mL dilution acid and the solutions were transferred quantitatively to 25mL volumetric flask. Then, it was diluted to volume with dilution acid. The spectrometer was set to condition specified by manufacturer. The standards and samples were analysed using Elan DRC II Inductively coupled plasma-mass spectrometry (NIOSH Method 7300, 2003).

Unit measure from ICP-MS was in ppb or mg/m^3. In order to get the exact value for chromium and nickel concentration, the formula stated as followed.

$$C = \frac{CsVs - CbVb}{V}, mg/m^3$$

Where,

C = concentration

C_s = concentration of sample

C_b = average media blank

V_s = volumes of sample

V_b = volume of blank

V = air volume sample

3.5.4 Blood Pressure

Blood pressure had been measured to determine the level of blood pressure which is related to Cr and Ni concentration presence in blood. Respondents had been asked to rest for 5 min and not drink or smoke for at least 30 min. Each respondent had three blood pressure readings and mean of systolic BP and diastolic BP will be calculated using the last two readings. The gold standard for clinical blood pressure measurement has always been readings taken by a trained health care provider using a mercury sphygmomanometer and the Korot-koff sound technique (Rogoza et al. 2000).

3.6 Data Analysis

All the data obtained were coded and analyzed using the Statistical Package for Social Science (SPSS) version 22. Kolmogorov-Smirnov statistical analysis was used to test normality for all data as the study sample was 138 respondents. Univariate, bivariate and multivariate testing were performed to answer the study objectives. Descriptive analysis was used to explore and analyse socio-demographic data and other related variables collected from the respondents and to determine mean value, standard deviation and frequency. Correlation test (Pearson Correlation) was performed to determine the correlation between individual air chromium and nickel concentration in individual air sample, blood and blood pressure of workers.

For multivariate analysis, a multiple linear regression was used to determine the relationship between the selected variables with the dependent variables.

3.7 Quality Control

3.7.1 Questionnaire

Pre-test had been conducted to the respondents which were more than 10% of the sample size which had the same population but at different place. This had been conducted in order to increase the quality of the questionnaires for this study. While for the interview session, practiced on interviewing respondents had been done by the researcher to make sure the researcher was used with the questions that will be asked by the respondents.

3.7.2 Blood Sample and IC-MS Analyse Method

Blood sampled were analysed based on standard operating procedure to prevent any infection to the respondent. For the instrumentation, the samples were analyzed by using ICP-MS and all the samples were duplicated to ensure the precision of the test result. The spectrometer was calibrated according to manufacturer's recommendations. Typically, acid blank and 10 µg/mL multielement solutions were used. The standard solution had been used for analysing for every ten

samples. Measurement recoveries had been checked for all elements of interest with at least three spiked.

3.7.3 Personal Air Sampling and ICP-MS Analyse Method

For the instrumentation, the samples were analyzed by using ICP-MS and all samples were duplicated to ensure the precision of the test result. The spectrometer had been calibrated according to manufacturer's recommendations. Typically, acid blank and 10 µg/mL multi element solutions were used. The standard solution had been used for analysing for every ten samples. Measurement recoveries had been checked for all elements of interest with at least two spiked blank filters per ten samples.

3.7.4 Blood Pressure

Respondents were asked to rest for 5 min and not drink or smoke for at least 30 min. Each respondent had three blood pressure readings which had been taken by medical doctor and mean of systolic BP and diastolic BP were calculated using the last three readings.

3.8 Ethical Approval

- Obtained approval from the Medical research Ethic Committee, University Putra Malaysia (UPM).
- Obtained permission and approval letter from the factory in the Kawasan Perindustrian Nilai, Negeri Sembilan which is the study was conducted.
- The management and respondents were informed about the purpose of the study through presentation and talk about the study and also the procedure from medical doctor because involving biological sample.
- The invasive procedures were carried out by qualified medical health doctor.
- Written consent was obtained from the respondents prior to study.
- Brief to the study subjects and ensure they understand the procedure and instruction that have been given to them before the blood sampling process.
- The collected information were kept during the study in confidentiality and only to use it within context of study.
- Privacy of information gathered was protected at all phases of this study and confidentially of respondents was upheld at all times of the study.

3.9 Study Limitation

There were some limitations through this study which were listed below:

- There were many other sources of metal exposure in factory from different other work activity or processes because the raw material in metal bearing itself contained molybdenum, iron, chromium, nickel, sulphur, phosphorus and many other which also can affect workers health.
- Most of the factory worker was a smoker which was difficult to exclude them due to the sample size constraint.
- There were many other confounding factors for this study such as age, BMI, and smoking habit.
- Time constraint for data collection as well as laboratory work for data analysis

CHAPTER 4

RESULT

4.1 Study Background

This study was conducted in order to determine the relationship between individual chromium and nickel concentration in air sample with blood and blood pressure level in metal machining industry. This cross-sectional study was carried out at one of the machining industry at Nilai, Negeri Sembilan. The factory mainly involved metal working process that used metalworking fluid as the coolant to increase tool life, wash away removed metal cuttings, protect tools from corrosion, reduce friction and improve the overall finish of the work piece (Sandin and Mattsbybaltzer, 1991). After screening for the inclusive criteria, the total respondents that agreed to participate in this study were 169 respondents. The inclusion criteria in this study were workers that have no medical history and deal with or work near the metalworking fluid which were used in metal machining process. However, only

total of 138 respondents that was willing to participate fully in this study for blood collection and analysis.

4.2 Response Rate

After screening for the inclusive criteria, the initial samples of respondents which have agreed to participate in this study and fulfilled the inclusive criteria were about 169 workers. However, only total of 138 male respondents was willing to participate fully in this study for blood collection and analysis which made the response rate was 81.66% and the remaining of the respondents were excluded.

4.3 Descriptive Characteristic of the Respondents

4.3.1 Socio-demographic Information

Data collection for socio-demographic information was conducted using self-administered questionnaire and interview. There were about 138 male respondents involved in this study which comprised 101 Malay (73.2%) respondents and the remaining were 32 Indian (23.2%) and 5 Chinese (3.6%) who works in machining section. The minimum age for total respondents was 20 years old while the

maximum age was 57 years old and 62% of the total respondents were ranged from 20 – 30 years old.

About 94% of the respondents were married. The education levels of the respondents were generally high, mostly in tertiary level (67.4%). Most of the respondents were overweight (43.5%). For monthly income, most of the workers have high pay for monthly salary. Majority of the workers were paid in a range of RM 1000 to RM 2000 monthly which made up 45.7% of the total respondents. Based on Table 4.1, about 41.3% of the respondents were paid in a range of RM 2000 to RM 3000.

Table 4.1: Socio-demographic Characteristic of the Respondents

Variables	n (%)	Mean (SD)	Min	Max
Age				
20 – 30	62 (44.9)	36.22 (10.56)	20	57
31 – 40	14 (10.1)			
41 – 50	52 (38.4)			
51 – 60	9 (6.5)			
Total	138 (100.0)			

Table 4.1: Socio-demographic Characteristic of the Respondents

Variables	n (%)	Mean (SD)	Min	Max
Ethnicity				
Malay	101 (73.2)			
Indian	32 (23.2)			
Chinese	5 (3.6)			
Total	138 (100.0)			
Marital Status				
Single	44 (31.9)			
Married	94 (68.1)			
Total	138 (100.0)			
Education level				
Primary	5 (3.6)			
Secondary	40 (29.0)			
Tertiary	93 (67.4)			
Total	138 (100.0)			
Body mass index (BMI)				
Underweight (<18.5)	4 (2.9)	26.30 (5.13)	17.21	52.88
Normal (18.5 – 24.9)	53 (38.4)			
Overweight (25 – 29.9)	60 (43.5)			
Obese (≥30)	21 (15.2)			
Total	138 (100.0)			

Table 4.1: Socio-demographic Characteristic of the Respondents

Variables	n (%)	Mean (SD)	Min	Max
Income				
<RM1000	4 (2.9)			
RM1000 – RM2000	63 (45.7)			
RM2000 – RM3000	57 (41.3)			
>RM3000	14 (10.1)			
Total	138 (100.0)			

N = 138

4.3.2 Lifestyle Information

Referring to Table 4.2 below, about 77% of the respondents were smokers. Out of 138 respondents, only 5.8% of them take alcohol.

Table 4.2: Lifestyle Information of the Respondents

Variables	Frequency	Percentage
Smoking status		
Yes	60	43.5
No	77	55.8
Total	138	100.0
Alcohol intake		
Yes	8	5.8
No	130	94.2
Total	138	100.0

N = 138

4.3.3 Working Information

Based on Table 4.3, most of the selected respondents for this study were techinician in the machining section which comprised 94.9% of the total respondents. The rest of the respondents were cleaner, engineer and maintenance in the machining section at the factory. There were about 13 work sections in which metalworking fluids were used in the machining section. Majority of the selected respondents worked at DGBB Channel 4 (13%). The distributions of respondents work station were shown in Table 4.3.

As for current working information, majority of the respondents have been working in the factory for 6 months to 5 years (47.1%). Most of them worked as long as 8 hours a day which was about 58% of the respondents while 42% of them worked 12 hours a day. The distribution of employments years for previous job of the respondents were shown in Table 4.4. Majority of the respondents have about 6 months to 5 years past employment years which were 52.2% of them. SABB Channel 1 and SABB Channel 6 have the highest number of MWF machine among the other job sections which were 10 machines, whereas LSR section has the lowest number of MWF machine which was 4 machines (Table 4.5).

Table 4.3: Job Task and Work Sections

Work Sections	Frequency (n)	Percentage (%)
Job's Title		
Technician	131	94.9
Maintenance	2	1.4
Engineer	2	1.4
Cleaner	3	2.2
Total	138	100.0
Work sections		
All Plant	14	10.1
LSR	4	2.9
DGBB Channel 2	5	3.6
DGBB Channel 3	10	7.2
DGBB Channel 4	18	13.0
SABB Channel 1	17	12.3
SABB Channel 6	6	4.3
SABB Channel 7	13	9.4
SRB Soft Ring	5	3.6
SRB Hard Ring	15	10.9
SRB Roller 1	7	5.1
SRB Roller 2	16	11.6
SRB Roller 3	8	5.8
Total	138	100.0

N=138

Table 4.4: Working Information of the Respondents

Variables	Frequency	Percentage
Employment years		
6 months – 5 years	65	47.1
5 years – 10 years	13	9.4
10 years – 20 years	32	23.2
≥20 years	28	20.3
Total	138	100.0
Past employment years		
0 month	32	20.8
<6 month	28	18.2
6 month - 5 years	79	51.3
5 - 10 years	11	7.1
10 - 20 years	4	2.6
Working duration		
8 hours	80	58.0
12 hours	58	42.0
Total	138	100.0

N = 138

Table 4.5: The Distribution of Machines in Each Section

Work Sections	Number of Machine	
	Frequency (n)	Percentage (%)
LSR	4	4.76
SABB Channel 1	10	11.90
DGBB Channel 2	6	7.14
DGBB Channel 3	8	9.52
DGBB Channel 4	7	8.33
SABB Channel 6	10	11.90
SABB Channel 7	8	9.52
SRB Soft Ring	6	7.14
SRB Hard Ring	5	5.95
SRB Roller 1	7	8.33
SRB Roller 2	8	9.52
SRB Roller 3	5	5.95
Total	84	100.0

N = 84

4.3.4 Health Symptoms Information

The health symptoms of respondents were obtained by using the questionnaire. Respiratory symptoms and skin symptoms of respondents were assessed during the interview session. Some examples of respiratory symptoms are cough, phlegm chest tightness and wheezing. In addition, some examples of skin symptoms are rashes, itching and inflammation.

The highest report of respiratory symptoms was cough (42.0%), followed by wheezing (37.7%), phlegm (25.4%) and chest tightness (24.6%). Whereas, the highest complaint was skin symptoms which were itching (39.9%).Other skin symptoms were rashes (39.1%) and inflammation (23.9%).

Table 4.6: Health Symptoms Information

Variables	Frequency (n)	Percentage (%)
Respiratory Symptom		
Cough		
Yes	24	17.4
No	114	82.6
Phlegm		
Yes	25	18.1
No	113	81.9
Chest Tightness		
Yes	28	20.3
No	110	79.7
Wheezing		
Yes	40	29.0
No	98	71.0
Skin Symptom		
Rashes		
Yes	54	39.1
No	84	60.9
Itching		
Yes	55	39.9
No	83	60.1
Inflammation		
Yes	33	23.9
No	105	76.1

N= 138

4.4 Individual Chromium and Nickel Concentration in Air and Blood Samples

The personal air sampling were carried out for 8 hours and placed within personal breathing zone of the workers. Based on Figure 4.1 (a), the median for personal air chromium was 1.712 mg/m^3, the mean (SD) was 1.712 (0.621) mg/m^3. The graph was not normally distributed using Kolmogorov-Smirnov normality test ($p<0.05$). The minimum and maximum concentrations of personal chromium in air sample were 0.168mg/m^3 and 2.902mg/m^3 respectively. Result for minimum and maximum individual air nickel sample based on Figure 4.1 (b) were 0.075 mg/m^3 and 0.924 mg/m^3 respectively while the mean (SD) was 0.318 (0.172) mg/m^3. Based on the results, all of the 138 male workers exposed to high concentration of chromium which exceeded the standard limit 0.05 mg/m^3 and only 7 workers that exposed to nickel concentration in the air below the standard limit which was 0.1 mg/m^3.

The concentration of chromium and nickel in blood were analysed using inductively coupled plasma-mass spectrometry (ICP-MS). The minimum and maximum concentrations of chromium in blood sample were 203.20µg/L and 1306.60µg/L respectively. In Encyclopedia of Occupational Health and Safety, 4th edition (1998) published by the International Labour Office has mentioned the values in serum and urine does not exceed 0.05 µg/100ml and 2.00 µg/g creatinine,

respectively (ILO, 1998). In the absence of exposure, whole blood chromium concentrations are in the range of 2.0 µg/100 mL to 3.0 µg/100 mL (Feldman *et al.*, 1967). Based on the results, chromium in workers whole blood were above the normal range.

The graph in Figure 4.1 (c) was not normally distributed using Kolmogorov-Smirnov normality test ($p<0.05$) and this showed that mean (SD) for blood chromium was 883.148 (267.649) µg/L. Based on Figure 4.1 (d), the minimum and maximum of blood nickel concentration were 61.60g/L and 430.40µg/L respectively. The mean (SD) for blood nickel was 153.220 (75.473) µg/L and median was 141.20 µg/L. The normal range of nickel in whole blood was 2.0µg/L in healthy person (ATSDR, 1988). Based on the results, nickel in workers whole blood was above the normal range.

Figure 4.1 (a): Distribution of Individual Chromium Concentration in Air Sample

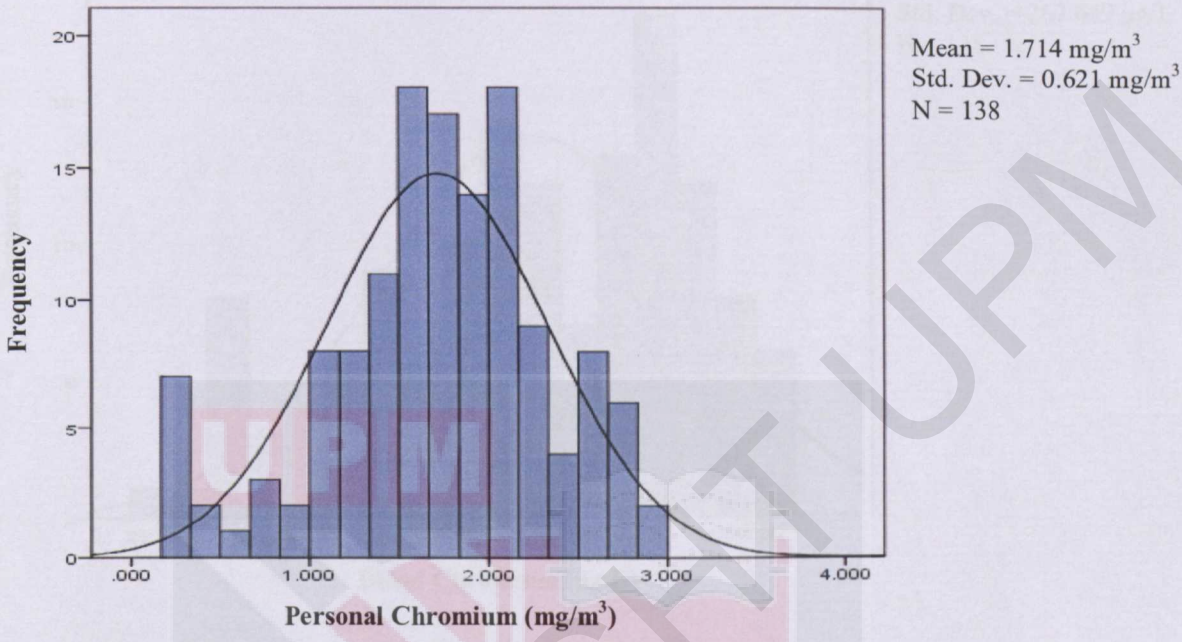


Figure 4.1 (b): Distribution of Individual Nickel Concentration in Air Sample

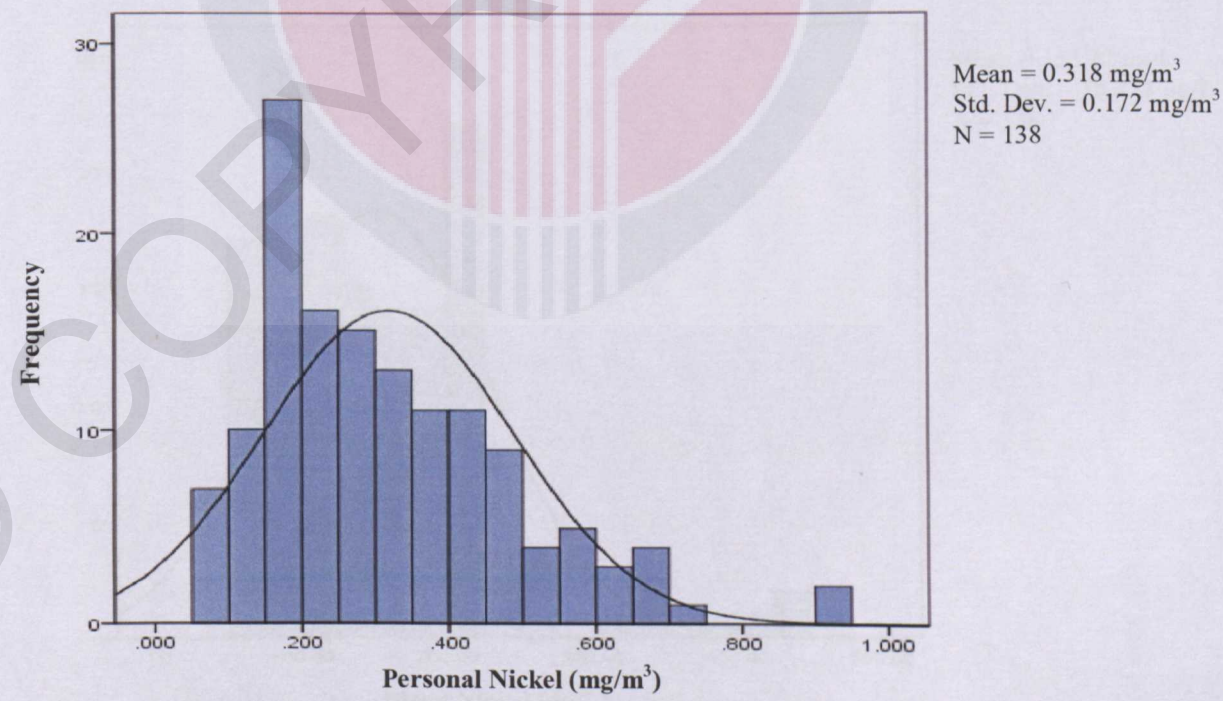


Figure 4.1 (c): Distribution of Blood Chromium Concentration

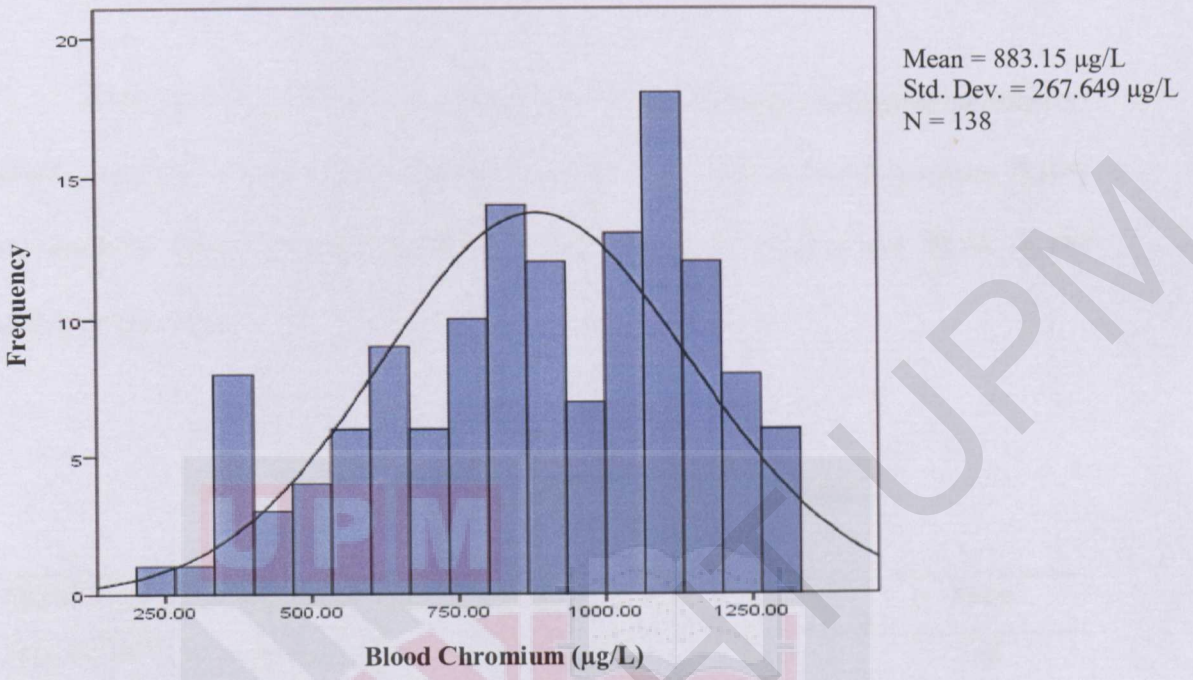
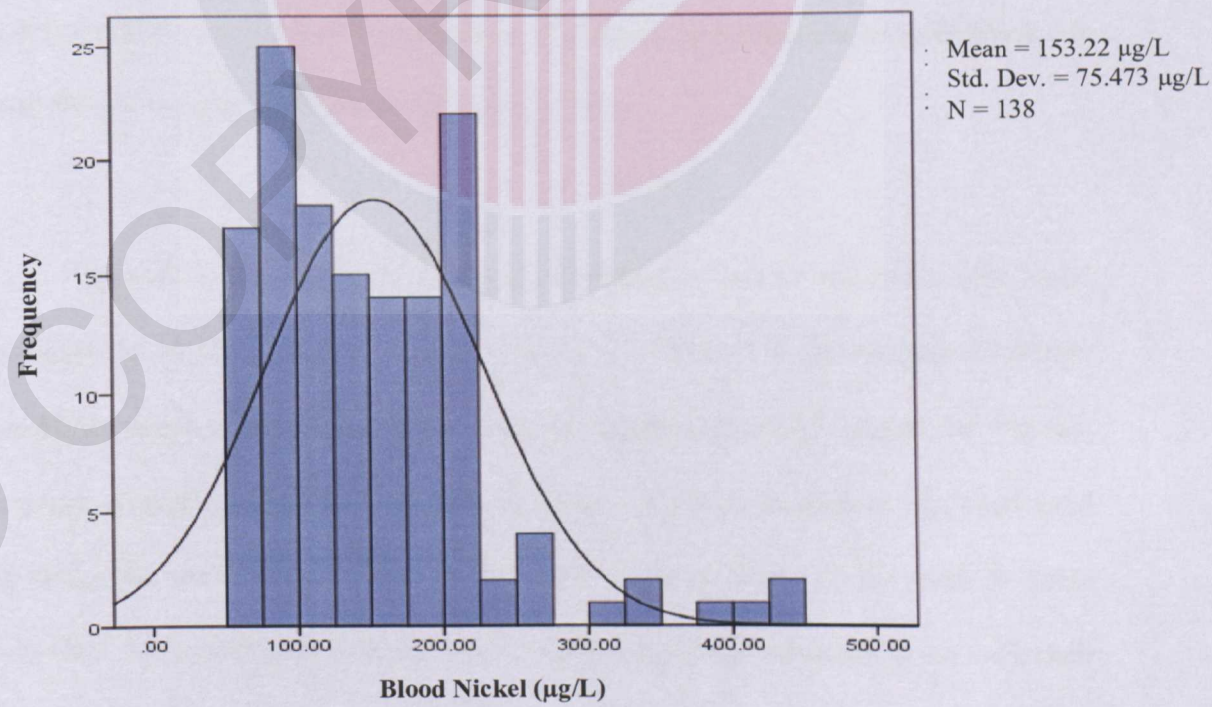


Figure 4.1 (d): Distribution of Blood Nickel Concentration



4.5 Blood Pressure Level

Blood pressure level was carried out using mercury sphygmomanometer. Based on Table 4.7, mean and standard deviation of systolic blood pressure (SBP) and diastolic blood pressure (DBP) were 127.46 (8.72) mmHg and 80.64 (6.15) mmHg respectively.

Table 4.7: Blood Pressure Level of Respondents

Blood Pressure Level (mmHg)	Mean (SD)	Min	Max
Systolic Blood Pressure (SBP)	127.46 (8.72)	110	148
Diastolic Blood Pressure (DBP)	80.64 (6.15)	70	100

N = 138

4.6 Correlation between Chromium and Nickel Concentration in Individual Air and Blood Sample with Blood Pressure Level.

Correlation between chromium in individual air sample and blood with blood pressure level were carried out as shown in Table 4.8. Kolmogorov-Smirnov normality test was conducted on the selected variables. Findings showed that the data was not normally distributed. Therefore, Spearman's Rho correlation was conducted to determine correlation between the selected variables. Based on the result in Table 4.8, there was significant relationship between individual chromium in air with their

blood sample (p=0.021). There were no significant correlation between systolic blood pressure (SBP) and diastolic blood pressure (DBP) with blood chromium (p>0.05).

Table 4.8: Correlation between Chromium Concentration in Individual Air and Blood Sample with Blood Pressure Level.

Variables	Blood Chromium (µg/L)	
	r-value	p-value
Individual Chromium in Air (mg/m^3)	0.197	0.021*
SBP (mmHg)	0.121	0.156
DBP (mmHg)	-0.022	0.800

Spearman-rho test

* Significant at p<0.05

A Spearman's Rho correlation test was performed to determine the correlation between nickel concentration in individual air and blood sample with blood pressure among respondents in machining industry. Outcome of the test showed that (Table 4.9), there was a significant correlation between individual nickel in air and blood sample (p=0.018) but the correlation was negligible or poor as the r-value was negative. On the other hand, there was no significant correlation between blood nickel and SBP or DBP (p>0.05).

Table 4.9: Correlation between Nickel Concentration in Individual Air and Blood Sample with Blood Pressure Level.

Variables	Blood Nickel (µg/L)	
	r-value	p-value
Individual Nickel in Air (mg/m^3)	-0.200	0.018
SBP (mmHg)	-0.006	0.942
DBP (mmHg)	-0.052	0.543

Spearman-rho test

* Significant at $p<0.05$

4.7 The Relationship between Selected Variables with Blood Pressure Level among Respondents

In the analysis, the dependent variable was systolic blood pressure (SBP) level while for independent variables were blood chromium, blood nickel, body mass index (BMI), income, smoking status, work duration, work experience, and past work experience. Multiple Linear Regression (MLR) test were used to determine which selected variables significantly influenced the systolic blood pressure levels after adjusting for all the confounders (Table 4.10). The result showed that, there was significant relationship between BMI and SBP level (p=0.019). There was also significant relationship between smoking status and SBP level (p=0.023).

Table 4.10: Relationship between Selected Variables with Systolic Blood Pressure (SBP)

Variables	Coefficient regression β	*t*	*p*	*F*	*p*
Constant		191.20	p<0.001	2.651	0.010
BCr	0.096	1.092	0.277		
BNi	-0.045	-0.506	0.614		
BMI	0.198	2.369	0.019*		
Income	-0.064	-0.578	0.564		
Smoking Status	0.191	2.297	0.023*		
Work Duration	-0.124	-1.483	0.140		
Employment Years	0.187	1.683	0.095		
Past Employment Years	0.005	0.056	0.956		

N= 138
Multiple linear regressions (enter)
*Significant at $p < 0.05$

In order to identify selected variables which significantly influence the diastolic blood pressure (DBP) level, Multiple Linear Regression "Enter Method" was utilized. The dependent variable used was diastolic blood pressure level while blood chromium, blood nickel, body mass index (BMI), income, smoking status, work duration, work experience, and past work experience were the independent variables. Table 4.11 showed there was significant relationship (p= 0.010) between

BMI and DBP level. Significant relationship was also found between work duration and DBP level (p=0.044).

Table 4.11: Relationship between Selected Variables with Diastolic Blood Pressure (DBP)

Variables	Coefficient regression β	*t*	*p*	*F*	*p*
Constant		17.552	p<0.001	2.400	0.019
BCr	-0.061	-0.687	0.493		
BNi	-0.028	-0.316	0.753		
BMI	0.219	2.601	0.010*		
Income	0.007	0.065	0.948		
Smoking	0.136	1.626	0.106		
Work Duration	-0.172	-2.035	0.044*		
Employment Years	0.085	0.757	0.450		
Past Employment Years	0.047	0.542	0.589		

N= 138
Multiple linear regressions (enter)
*Significant at $p < 0.05$

4.8 Relationship between Selected Variables with Blood Chromium and Nickel Concentration

In order to determine the relationship between blood chromium and selected variables, multiple linear regressions was used. After controlling all the factors, there were significant relationship between individual air chromium and blood chromium (p=0.012). There was also significant relationship between employment years and blood chromium (p=0.044).

Table 4.12: Relationship between Selected Variables with Blood Chromium

Variables	Coefficient regression β	*t*	*p*	*F*	*p*
Constant		6.159	p<0.001	1.997	0.083
Individual Air Chromium	0.220	2.536	0.012*		
Age	0.278	1.802	0.074		
Smoking Status	0.072	0.845	0.399		
Work Duration	-0.068	-0.799	0.425		
Employment Years	-0.315	-2.031	0.044*		

N= 138
Multiple linear regressions (enter)
*Significant at $p < 0.05$

In order to determine the relationship between blood nickel and selected variables, multiple linear regressions was used. Variables that were studied were the individual air nickel, age, smoking status, work duration and employment years.

Results showed, there was only significant relationship between blood nickel and individual air nickel (p=0.024).

Table 4.13: Relationship between Selected Variables with Blood Nickel

Variables	Coefficient regression β	*t*	*p*	*F*	*p*
Constant		5.551	p<0.001	1.262	0.284
Individual Air Nickel	-0.196	-2.278	0.024*		
Age	-0.048	-0.307	0.759		
Smoking Status	-0.067	-0.776	0.439		
Work Duration	-0.007	-0.087	0.931		
Employment Years	0.082	0.528	0.599		

N= 138
Multiple linear regressions (enter)
*Significant at $p < 0.05$

4.9 Relationship between Selected Variables with Individual Air Chromium and Nickel of the Workers

Dependent variable was individual air chromium (Table 4.14) while for independent variables were number of machine in each section, job section, work duration and total metalworking fluid used in each section. Multiple linear regressions was used to determine which selected variables significantly influenced the individual air chromium after adjusting for all the confounders There was strong

significant relationship between individual air chromium and number of machine in each section ($p<0.001$).

Table 4.14: Relationship between Selected Variables with Individual Air Chromium

Variables	Coefficient regression β	t	p	F	P
Constant		4.594	p<0.001	3.335	0.012
No. of Machine in Each Section	0.407	3.303	p<0.001*		
Job Section	0.196	1.552	0.123		
Work Duration	0.066	0.777	0.439		
Total MWF Used in Each Section	-0.259	-1.965	0.051		

N= 138
Multiple linear regressions
*Significant at $p < 0.05$

Relationship between individual air nickel and selected variables was analysed using multiple linear regressions. Variables that were selected were the number of machine in each section, job section, works duration and total metalworking fluid used in each section. Based on the result, there was no significant relationship between individual air nickel and selected variables.

Table 4.15: Relationship between Selected Variables with Individual Air Nickel

Variables	Coefficient regression β	*t*	*p*	*F*	*p*
Constant		5.174	p<0.001	0.919	0.455
No. of Machine in Each Section	-0.149	-1.168	0.245		
Job Section	-0.165	-1.260	0.210		
Work Duration	0.059	0.666	0.507		
Total MWF Used in Each Section	0.046	0.335	0.738		

N= 138

Multiple linear regressions (enter)

*Significant at $p < 0.05$

CHAPTER 5

DISCUSSION, CONCLUSION AND RECOMMENDATION

5.1 Discussion

5.1.1 Socio-demographic information

This study involved 169 workers randomly selected from the machining section and fulfilled the inclusion criteria, however 18.34% of the respondents were excluded as they did not want to participate in blood collection. Thus, final total respondents for this study were 138 respondents. So, study was carried out among 138 male subjects who had been occupationally exposed to metalworking fluid in metal machining process. The inclusion criteria of this study were workers that exposed to metalworking fluid in metal machining process and healthy. The exclusion criteria of respondent's selection were the workers that did not have diabetes, high blood pressure, and thyroid. The response rate was 81.66%.

All subjects gave informed consent before inclusion in the study. The study was performed in accordance with ethical approval from Universiti Putra Malaysia ethical committee. A self-constructed questionnaire including data on personal information, basic demographic and occupational information and medical history was completed for each of the 138 subjects. The selection of respondents involved only male workers who participated in this study. This was to avoid any confounder factors between genders, besides, the majority workers in the factory was male. All the study subjects were Malaysian consisting of 101 Malays, 32 Indians and 5 Chinese who worked in the metal machining factory. Most of the respondents were from age range between 20 to 29 years old which was about 40.6% of the total respondents.

All of the selected respondents had at least attended school before, whereby the highest education was the tertiary level with diploma and degree (67.4%). This was due to the requirement by the employer in hiring their employees. Most of the work process required workers to operate a machine and hence employee should at least to be literate, have knowledge on machines or attended a school.

The study group could be regarded representative to the general population. Body height and weight were measured for each subject and BMI (kg/m^3) was calculated. Based on the previous study result, there were 60 workers that have overweight BMI and only 4 workers in the range of underweight. BMI was

positively associated with blood pressure in seven out of the eight analyses in the Yanomamo (both SBP and DBP) and Kenyans (DBP) (Jaiharo *et. al*, 1989).

The range of worker's monthly income was quite wide as the lowest was less than RM 1000 and the highest was more than RM 3000. The worker's income per month depended on the workers experience, job title and the total hour of work a month. Majority of incomes were between RM 1000 to RM 2000 per month since most of them were young age between and 20 years old to 29 years old, with less than 5 years. There were 60 smokers and 77 non-smokers, 8 alcohol consumers and 130 non-consumers of alcohol. Alcohol consumption was not associated significantly with blood pressure (Jaiharo *et. al*, 1989).

About 94.9% of the selected respondents were a technician. This was due to the majority of the workers at the machining section which were technician. There were about 13 work sections that used the metalworking fluids production activities in the machining section namely SABB 1, SABB 6, SABB 7, DGBB 2, DGBB 3, DGBB 4, SRB 1, SRB 2, SRB 3, SRB Soft Ring, SRB Hard Ring, LSR and All Plant. Majority of the selected respondents (13%) were working at DGBB Channel 4. Since most of the respondents were in the age range of 20 to 29 years, thus, majority of the respondents have less than 5 years (47.1%) of experience. There were two types of common working hours in the factory which were 8 and 12 hours per day. About 58% were working for 8 hours per day and have two break times within 15 –

20 minutes for each break time. Some of them also were working for 12 hours per day (42%) with three break times.

Respondents in this study involved the workers who handled machine and operated the product in order to fulfil the requirement and production target by company. Their task included of loading the raw material into the machine, maintenance and housekeeping. Most of the machines were automated and workers only have to press button to run the machine. However, the employee was regularly exposed to MWFs because there was a splash of MWFs particles from the machine even though there were close guarding on the machine. It becomes worst when the technicians did the maintenance on the machine and at the same time they would open the guarding in order to facilitate maintain the job task. Sometimes the workers would directly touch MWFs with bare hands without using any safety devices such as rubber glove which have been provided.

Most of the SABB section had higher number of MWF machine in each section. SABB 1 and SABB 2 have the highest number of MWF machine among the other job sections with 10 machines, whereas LSR section has the lowest number of MWF machine which was 4 machines.

5.1.2 Individual Chromium and Nickel Concentration in Individual Air and Blood Samples

The workers that work or deal with metalworking fluid while operating the metal machining process were being exposed to the metal contaminant such as chromium and nickel. Exposure to metalworking fluids, or their individual components, has been associated with the airway function impairment. Various agents in metalworking fluids have been implicated, for example, mineral oil, gram-negative bacteria, endotoxin, fungi, biocides, tramp oil, pine oil, emulsifiers, ethanol-amines, and metal contaminants from the machining process. However, the nature and magnitude of the exposure-response relationships are not completely understood (Abrams *et. al,* 2000).

The occupational safety and health administration (OSHA) and the national institute for occupational safety and health (NIOSH) establish permissible exposure limits (PELs) and recommended exposure limit (RELs), respectively, for hazardous substances in the workplace. PEL were based on feasibility of controlling the exposure in question within workplace, while RELs were based on requirements for preventing occupational disease. Eight-hour time-weighted average (TWA) airborne concentration of chromium was 0.05mg/m^3 while for nickel concentration was 0.1 mg/m^3 (USECHH, 2000).

The personal air sample were carried out for 8 hours and placed within personal breathing zone of the workers. Based on result, the mean (SD) for personal air chromium was 1.712 (0.621) mg/m^3. The range concentrations of individual chromium in air sample were 0.168mg/m^3 to 2.902mg/m^3. Based on the result obtained, all the 138 workers (100%) have chromium personal air concentration exceed the 8-hour TWA standard for air chromium concentration. Occupational exposure to chromium primarily occurs from chromate production, stainless steel production and welding, chromium plating, ferrochrome alloys, and chrome pigment production. Workers in the bearing industries are also potentially exposed to chromium.

Range for concentration of individual nickel in air samples were 0.075 mg/m^3 to 0.924 mg/m^3 while for mean (SD) was 0.318 (0.172) mg/m^3. Based on the result for individual nickel in air sample, only 7 (5.07%) respondents have nickel concentration below the 8-hour TWA airborne concentration while 131(94.9%) of the respondents were exceed the 8-hours TWA standard for air nickel concentration that has been recommended. The workers also may be exposed to nickel by breathing dust or fumes (as from welding) or by skin contact with nickel-containing metal and dust or solutions containing dissolved nickel compounds (ATSDR, 2005).

Result of high concentration of chromium and nickel in the air sample was associated with the present of high chromium and nickel in the raw material in metal bearing of the products itself. Based on verbal conversation with the Quality Control

Officer of the factory, chromium and nickel were the highest elements that contained in the raw material which made up 18% and 9% by weight respectively. This showed that, the presence of chromium and nickel in the air was directly from the aerosol as a result of cutting, grinding and washing of the raw material in metal bearing in order to produce bearing products. The aerosol produced from metal work process contaminates the air of the workplace.

The blood chromium and nickel were analysed using inductively coupled plasma-mass spectrometry (ICP-MS). The range of blood chromium samples were 203.20µg/L to 1306.60µg/L. In the absence of exposure, whole blood chromium concentrations are in the range of 2.0 µg/100 mL to 3.0 µg/100 mL (Feldman *et al.*, 1967). Based on the results, chromium in workers whole blood were exceed the normal range as the mean (SD) for blood chromium was 883.148 (267.649) µg/L. This high chromium concentration may partly be attributed to concomitant exposure to other metals and their interaction especially in industrial areas as well as different dietary habits and contents of other metals in food. Chromium rapidly clears from the blood and measurements relate only to recent exposure. In a recent review, (Danadevi *et al.*, 2004; Huvinen *et al.*, 2002) a chromium exposure up to about 5000 $\mu g/m^3$ in the chromium plating industry was mentioned, but most exposure levels reported were in the range of 100-200$\mu g/m^3$ (NIOSH, 1973). In modern plants, values are often less than 10$\mu g/m^3$ (IARC, 1980).

In occupational settings, the most commonly reported effects of chronic chromium exposure were contact dermatitis, irritation and ulceration of the nasal mucosa (Danadevi et al., 2003; Kumar et al., 2005). This was correlated with respondents complained as they having respiratory problems such as wheezing (29%), chest tightness (20.3%) and phlegm (18.1%). The most sensitive targets of chromium (VI) were the respiratory, gastrointestinal, hematological, and reproductive systems. The primary targets of chromium (III) compounds were the respiratory and immunological systems. Chromium allergic dermatitis is typically elicited by dermal contact in sensitized individuals. This was accordance to health symptoms that been reported by the respondents as 39.9% of the total respondents complained they having itching symptoms and 39.1% having rashes that being exposed to high chromium concentration.

The range of blood nickel concentrations was 61.60g/L to 430.40µg/L. The mean (SD) for blood nickel was 153.220 (75.473) µg/L and this value exceed the normal range of nickel in whole blood which was 2.0µg/L in healthy person (ATSDR, 1988). Based on the results, nickel in workers whole blood was above the normal range. Ni content in air and that of biologic fluids of the SS welders However, in post shift samples they found a correlation between Ni in the plasma and the urine, the correlation coefficient being 0.294 (Stridsklev *et. al.*, 1993).

Occupational exposure to nickel may occur by dermal contact or by inhalation of aerosols, dusts, fumes, or mists containing nickel. Dermal contact may

also occur with nickel solutions. Occupational exposure to nickel will be highest for those involved in production, processing, and use of nickel. Operations with the highest airborne concentrations of nickel are those involved in grinding, welding, and handling powders (ATSDR, 2005). The most commonly reported adverse health effect associated with nickel exposure is contact dermatitis as 39.9% of respondents complained them having itching and 39.1% having rashes symptoms. The toxicity of nickel in the respiratory tract appears to be related to solubility of the individual nickel compounds with soluble nickel compounds being the most toxic.

Thus, biomarkers can be indicators of the body burden of a chemical, reflecting all routes of exposure, as well as inter-individual differences in absorption and metabolism. Compared to external concentrations of chemicals, biomarkers were often believed to be more directly related to potential adverse health effects. Blood and urine samples were the most widely used and accepted matrices for biomonitoring heavy metal exposure in occupational and environmental toxicology (Gil and Pla, 2001; Gil and Hernandez, 2009). Environment and occupational particulate pollutants enter humans through the inhalation route depending on the size and shape which can be confirm by air sample. Therefore, characterization and evaluation of local biomarkers might help to verify occupational respiratory disease at a subclinical stage (Quirce *et al.*, 2009).

5.1.3 Blood Pressure Level

Blood pressure level was carried out using sphygmomanometer blood pressure meter. The mean and standard deviation of systolic blood pressure (SBP) and diastolic blood pressure (DBP) were respectively 127.46 (8.72) mmHg and 80.64 (6.15) mmHg. The range of SBP was 110mmHg to 148mmHg. On the other hand, the range of DBP was 70mmHg to 100mmHg. Based on the result there were 10 respondents that have more than 140mmHg for the systolic blood pressure while for the diastolic blood pressure there were 6 respondents above than 90mmHg.

Hypertension, was defined in adults (≥18 years of age) as a systolic blood pressure of ≥140mmHg or a diastolic blood pressure of ≥90mmHg (Chobanian *et al.*, 2003). Primary hypertension has no identifiable cause, there are known predisposing factors. The predisposing factors to primary hypertension include obesity, sedentary lifestyle, high salt intake, low calcium intake, low potassium intake, increasing age, low birth weight, familial predisposition, autonomic imbalance, and likely trace metals (Whelton, 1994).

5.1.4 Correlation between Chromium and Nickel Concentration in Individual Air and Blood Sample with Blood Pressure Level.

Correlation between chromium in individual air sample and blood with blood pressure level were carried out as shown in Table 4.8, Chapter 4. Kolmogorov-

Smirnov normality test was conducted on the selected variables. Findings showed that the data was not normally distributed. Therefore, Spearman's Rho correlation was conducted to determine correlation between the selected variables. Based on the result in Table 4.8, there was significant relationship between individual chromium in air with their blood sample ($p=0.021$). There were no significant correlation between systolic blood pressure (SBP) and diastolic blood pressure (DBP) with blood chromium ($p>0.05$). This positive correlation showed that the inhaled chromium in air was statistically correlated with amount of chromium in the blood.

These finding slightly supported by study which stated that hexavalent chromium is rapidly absorbed by the lungs via inhalation of airborne chromium into the blood and easily penetrates the cellular membranes, and binds to the haemoglobin in the red blood cells, after having been reduced to the trivalent state (Edme, 1997). Trivalent chromium in the air accounts probably only to a minor degree for the biological chromium values because chromium species other than the hexavalent were only resorbed to a small extent in the lung. The most outstanding findings was the direct correlation between bloods Cd with urine Cd and between Cd in axillary hair with Cr saliva while Cr in urine showed a positive correlation with Cr in blood and saliva (Fernandez *et al.*, 2011).

A Spearman's Rho correlation test was performed to determine the correlation between individual air nickel concentration and blood sample with blood pressure level among respondents in machining industry. Table 4.9 in Chapter 4

shows, there was a significant correlation between individual nickel in air and blood ($p=0.018$) but the correlation was negligible or poor as the r-value was negative. On the other hand, there was no significant correlation between blood nickel and SBP or DBP ($p>0.05$). Based on Spruit *et al.* (1977), the concentration of blood nickel plasma, urine, and hair were not significantly different between human subjects who were allergic to nickel and those who were not. In occupationally exposed subjects, however, the content of nickel in plasma, urine, and hair was higher than in controls, regardless of the hypersensitivity to the metal.

5.1.5 The Relationship between Selected Variables with Blood Pressure Level among Respondents

In the analysis, the dependent variable was systolic blood pressure (SBP) level while for independent variables were blood chromium, blood nickel, body mass index (BMI), income, smoking status, work duration, work experience, and past work experience. Multiple Linear Regression (MLR) test was used to determine which selected variables significantly influenced the systolic blood pressure levels after adjusting for all the confounders. The result showed that, there was positive significant relationship between BMI with SBP level ($p=0.019$). There was also significant relationship between smoking status with SBP level ($p=0.023$).

In order to determine the relationship between selected variables and diastolic blood pressure, MLR was carried out. The dependent variable used was diastolic

blood pressure level while blood chromium, blood nickel, body mass index (BMI), income, smoking status, work duration, work experience, and past work experience were the independent variables. Result showed there was significant relationship between BMI with DBP level (p= 0.010). There was an inverse significant relationship between work duration and DBP level (p=0.044).

Based on Dyer and Elliott (1989), body mass index and blood pressure relationships were first studied in men and women within each centre, and results of these regression analyses were then pooled for all 52 centres. With adjustment for age, alcohol intake, smoking, and sodium and potassium excretion, body mass index was positively associated with systolic blood pressure among men in 51 out of 52 centres and among women in 47 centres, significantly so in 24 and 27, respectively. Body mass index was positively associated with diastolic blood pressure among men in 51 and 49 centres in men and women, respectively, significantly so in 33 and 31. When the centre regression coefficients were pooled, the pooled coefficients were highly significant in all analyses ($p<0.001$), and were similar for those aged 20-39 and 40-59.

Overweight and obesity increase the risks of high BP, coronary heart disease, ischaemic stroke, type II diabetes mellitus and certain cancers. Worldwide about 58% of diabetes mellitus and 21% of ischaemic heart disease were attributable to BMI above 21kg/m^2 (WHO, 2002). The association between BMI and BP has been widely reported across populations in Asia, Latin America, United States and

Canada. In a study that included five Latin American populations (urban) and seven Asian populations (four urban, three rural), significant positive relationships of similar magnitude were observed between BMI and BP, despite differences in mean BMI levels between the populations studied (Mhurchu *et al.*, 2004).

The use of tobacco products remain major remediable risk factors in patients prone to the development of coronary artery disease and may with variety of the other coronary artery risk disease factors. Cigarette smoking has been implicated in the pathogenesis of ischemic heart disease. It has been found that the overweight-associated cardiovascular risk is substantially increased by exposure to other atherosclerotic risk factors, of which smoking seems to be the most important. In a study of 24-hour ambulatory blood pressure (BP) monitoring, smokers maintained a higher mean daytime ambulatory systolic BP (SBP) than non-smokers, even though the BP levels were similar (Mann *et al.*, 1991).

Cross-sectional analyses of data from the Framingham Heart Study showed that men who reported high workload, not supportive bosses, job changes, and promotions did not have elevated diastolic blood pressure (Haynes *et al.*, 1978). Studies on the relationship between shift work and hypertension were few, and they have been investigated with different groups and outcome measurements. The results, therefore, were inconsistent. In the present study by Chan *et al.* (1993), there was an association between work duration (shift work) and elevated diastolic blood

pressure were found. In contrast, there was no evidence of an association between shift work and hypertension found in a study of Singapore factory workers.

5.1.6 The Relationship between Selected Variables with Blood Chromium and Nickel Concentration

Relationship between selected variables with chromium in workers' blood sample was analysed using multiple linear regressions. Based on the results, blood chromium have positive significant relationship with individual air chromium ($p=0.012$). The regression coefficient related with individual air chromium was 0.220 suggesting that each one unit increased in individual air chromium was related with a 0.220 unit increased in blood chromium. The mean concentration of blood chromium was slightly higher than previous study and this indicated that chromium in individual air sample has relationship with the increase of blood chromium as what have been proven by the statistical analysis.

These finding slightly supported by Edme (1997) who stated that hexavalent chromium was rapidly absorbed by the lungs via inhalation of airborne chromium into the blood and penetrated easily into the cellular membranes, and binds to the haemoglobin in the red blood cells, after having been reduced to the trivalent state. Trivalent chromium in the air accounts probably only to a minor degree for the biological chromium values because chromium species other than the hexavalent were only resorbed to a small extent in the lung.

High concentrations of chromium in blood also have relationship with employment years (inversely) (p=0.044). This finding was supported by Alfridi *et al.* (2006) which stated that there was significant relationship between length of employment with blood chromium concentration as the result of comparative data of chromium in biological samples of 10 and 20 years employees showed constant values between two groups of employees. Based on the observations through site visit survey, high blood chromium concentration was related to not using personal protective equipment by the workers. Mostly of the workers not used their protective devices such as mask, rubber glove and ear muff which have been provided by the company. Chromium can be penetrated into the body by inhalation and skin absorption if safety device was improperly used and the employer also must ensured that the safety devices were suitable and comfortable to be used by the workers.

Based on the result, there were inverse relationship between blood and individual air nickel as the coefficient regression show that beta value was -0.196 (p=0.024). The urinary and plasma nickel concentrations were higher in the samples taken after than before the work shift and a close positive correlation was found between the air nickel concentrations with the urine and blood nickel concentrations, respectively. There was also a close correlation between urinary and blood nickel concentrations (Tola, 1979).

5.1.7 The Relationship between Selected Variables with Individual Air Chromium and Nickel of the Workers

Multiple linear regressions were used to determine which selected variables significantly influenced the individual air chromium after adjusting for all the confounders. There was a strong significant relationship between individual air chromium and number of machine in each section ($p<0.001$). The higher number of machine in work section can increase the concentration of metal in the workplace. Based on the observation, throughout the factory, most of the workers were highly exposed to the chromium and nickel aerosol in the air during maintenance work process as the workers have to open the machine and reset the reading and the machine to normal state. During the maintenance work, the workers were exposed to the aerosols that contain metal elements directly as the workers have to get into the machines that still contained the high residue of metal aerosol.

In the workplace, many aspects of the machine operation affected the workers' exposures to air contaminants. Information on a number of factors was collected along with the air samples. Machine type, metalworking fluid type, indoor humidity and outdoor temperature were all important in explaining the variance in exposure levels for all particle-size fractions. Neither worker distance from the metalworking fluid source nor age of the machine was significant in explaining the exposure level for any of the particle-size fractions (Susan, 1994).

Relationship between variables which were studied were the distance of the machine, number of machine in each section, job sections, works duration and total metalworking fluid used in each section with individual air nickel were done after controlling all the factor. There were no significant relationship between individual air nickel and selected variables that have been chosen which maybe because the air nickel concentrations were very low.

5.2 Conclusion

The means of chromium and nickel in individual air sample were mostly above the standard established and similar to chromium and nickel in blood. This study showed that, there was a statistically significant correlation between chromium in individual air and blood sample as well as individual nickel in air and blood samples even though there was poor correlation in nickel. There were statistically relationship between BMI and smoking status with systolic blood pressure. Work duration and BMI have statistically significant relationship with diastolic blood pressure among workers in metal machining industry. There were significant relationships between individual air chromium and employment years with blood chromium. There was significant relationship between individual air nickels with blood nickel. The numbers of the machine were significantly correlated with individual air chromium. Therefore, the chromium and nickel was most likely present in the aerosol of the MWF generated from the machine working processes.

5.3 Recommendation

5.3.1 Recommendation for Future Study

Based on this study, there were some recommendations that can be done to improve this study in the future. The recommendations were:

1. Control group can be added to compare the concentration of metal in biological samples among control and exposed group.
2. Female respondents can be included in order to determine the variability between gender in rate of absorption and metabolism when exposed to metal contaminants.
3. Specific form of the chromium (III, IV, V and VI) and nickel (soluble and insoluble) can be analysed to determine the effect of the specific form of metal when introduced into the human body.
4. Comparison between more factories that used metalworking fluid in their machining process will provide more comprehensive findings in future study.
5. Analyse other element that present in the factory which also can contribute to workers adverse health effect when exposed to metal contaminant (molybdenum, iron, manganese, phosphorus and sulphur).

6. Ingestion and absorption route of exposure also can be done in future study because absorption also main route of exposure as the workers exposed directly to the metal with bare hand which can cause dermal symptoms.

5.3.2 Recommendation for the Top Management of the Factory

It is essential to take up an action which aimed to minimize the risk of chromium and nickel contamination. Some of the actions that are recommended for the top management of the factory are as below:

1. Workers working with MWFs machine should have better respiratory protection since the individual air chromium and nickel significantly correlated with high blood chromium and nickel.

2. Organizing awareness programme for the machinists to highlight the hazard and danger when dealing or working with metalworking fluid machine.

3. Sections with high air chromium and nickel concentration should have better engineering protection on the machines and better personal protective equipment used by the workers.

4. Work duration can be reduced in order to reduce time of exposure to high concentration for chromium and nickel in the air by take a break after 2 hours handling the job task.

5. Improve the ventilation system of the production area in ensuring the effective exchange of air.

6. Regular housekeeping of workplace station can be done to improve the cleanliness of the workplace and reduce risk of adverse effects to the workers.

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APPENDIX 1

Ethic Committee Approval Letter

APPENDIX 2

Respondent's Information Sheet

JAWATANKUASA ETIKA UNIVERSITI UNTUK
PENYELIDIKAN MELIBATKAN MANUSIA (JKEUPM)
UNIVERSITI PUTRA MALAYSIA, 43400 UPM SERDANG,
SELANGOR, MALAYSIA

FORM B1: RESPONDENT'S INFORMATION SHEET AND CONSENT

Please read the following information carefully and do not hesitate to discuss any questions you may have with the researcher.

1. STUDY TITLE:

The Correlation between Individual Chromium and Nickel in Air Sample with Blood Chromium and Nickel and Blood Pressure Level among Machining Industry Workers at Nilai, Negeri Sembilan

2. INTRODUCTION:

Metal concentration in occupational origin is a cause from concern because of its potential accumulation in the environment and in living organisms leading to long term toxic effects. Metal machining requires lubrication and dispersion of generated heat. In addition to the materials that are purposefully introduced into metalworking fluids, numerous contaminants are known to appear with use, such as bacteria, fungi, and the metabolic products of viable organisms, trace metal contaminants from the metalworking process, and 'tramp oil' (lubrication oil that has leaked from machines performing metal working-processes) (Robins et al., 1997).

3. WHAT WILL YOU HAVE TO DO?

The respondent are required to answer the questionnaire to obtain the data information regarding on the study. 30 minutes will be given to complete the questionnaire. Medical examination will be conducted after each respondent have filled up their questionnaire. All respondent who meet the inclusion criteria will undergo blood sampling procedure after the medical check examination. 3 ml blood will be drawn from the cubital fossa by experienced medical health doctor and collect into sterile blood container to be tested for the metal contaminant in blood. The result or outcome of the blood sampling will be informed to the respondent later after the blood analysis.

Please initial here if you have read and understood the contents of this page__

4. WHO SHOULD NOT PARTICIPATE IN THE STUDY?

Individual with seniority of working less than 6 month, not working in machining section and having history of health problem or disease.

5. WHAT WILL BE BENEFITS OF THE STUDY:

(a) TO YOU AS THE SUBJECT?

It will help the organizational to aware on the hazard of metal contaminants from the usage of metalworking fluids in their work task. Thus, control measures could be planned to protect the worker's health.

(b) TO THE INVESTIGATOR?

It will help the investigator to determine whether chromium and nickel concentration in individual air sample and blood will be correlated with the workers blood pressure level in machining industry.

6. WHAT ARE THE POSSIBLE RISKS?

All the possible risk such as physical risk and infection from the invasive procedure has been considered and the safety measure during the blood sampling procedure has been set up. Thus, the possible risk of the study has been minimized.

7. WILL THE INFORMATION THAT YOU PROVIDE AND YOUR IDENTITY REMAIN CONFIDENTIAL?

The information obtained throughout the study will be informed to the employer and only to be use within this context of study which is not being revealed to other third party.

8. WHO SHOULD YOU CONTACT IF YOU HAVE ADDITIONAL QUESTIONS DURING THE COURSE OF THE RESEARCH?

If you have any additional questions, you may contact to Profesor Dr Zailina Binti Hashim, Supervisor of the study research at 017-6361367 or Nursyahidah binti Mohd Bashah, the researcher at 013-7670780.

*Please initial here if you have read and understood the contents of this page*__

9. CONSENT

I ..... Identity Card No. .....

address.....

.....hereby voluntarily agree to take part in the research stated above *(clinical /drug trial/video recording/ focus group/interview-based/ questionnaire-based).

I have been informed about the nature of the research in terms of methodology, possible adverse effects and complications (as written in the Respondent's Information Sheet). I understand that I have the right to withdraw from this research at any time without giving any reason whatsoever. I also understand that this study is confidential and all information provided with regard to my identity will remain private and confidential.

I* wish / do not wish to know the results related to my participation in the research

I agree/do not agree that the images/photos/video recordings/voice recordings related to me be used in any form of publication or presentation (if applicable)

* delete where necessary

Signature ..... Signature .....
(Respondent) (Witness)

Date :..... Name :.....

I/C No. :.....

I confirm that I have explained to the respondent the nature and purpose of the above-mentioned research.

Date ..... Signature .....
(Researcher)

APPENDIX 3

Study Gantt Chart

Year	2013				2014				
Planning/Month	**SEPT**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAC**	**APR**	**MAY**
Propose title for the project									
Submission of the proposal									
Proposal Presentation									
Permission letter to factory									
Receive Approval letter from the company									
Pre-tested questionnaire									
Submission of proposal to Ethical Committee for approval									
Presentation for Ethical Committee									
Approval letter from Ethical Committee									
Visit the factory									
Get consent from respondents and									
Data collection									
Data analysis									
Thesis writing									
Submission of thesis									

APPENDIX 4

Questionnaire Form

UNIVERSITI PUTRA MALAYSIA

FACULTY OF MEDICINE AND HEALTH SCIENCES

SECTION A: SOCIO-DEMOGRAFIC INFORMATION

Instruction: Please fill in the information below and tick (/) in a box given.

1. Name: _____

2. Sex

   ☐ Male ☐ Female

3. Age: _____ years old.

4. Race

	Malay
	Chinese
	Indian
	Others

5. Nationality

   ☐ Malaysian ☐ Foreign

6. Marital status

   ☐ Married ☐ Single

7. Weight ☐ Kg

8. Height ☐ cm

Section B: Smoking History

Instruction: Please fill in the information below and tick (/) in a box given.

1. Do you smoking?

   (At least 1 cigarettes a day or 20 packs per year)

   Yes ☐ No ☐

   If 'Yes' go to the next question. If 'No', go to Section C.

2. Do you still smoking last month?

   Yes ☐ No ☐

3. Average: how many cigarettes do you smoke a day?

   ☐☐ Cigarettes

SECTION C: WORK HISTORY

Instruction: Please fill in the information below and tick (/) in a box given.

I. Previous Job : _____

II. Job Description : _____

III. Years of Work :

☐ < 6 month
☐ 6 month – 2 year
☐ 2years – 4 years
☐ > 5 years

IV. Work Duration :

☐ < 5 hours
☐ 11 – 15 hours
☐ 6 – 10 hours
☐ >16 hours

SECTION D: RECENT WORKING INFORMATION

Instruction: Please fill in the information below and tick (/) in a box given.

1. Job Description : _____
2. Work Section : _____
3. Years of work

☐ < 6 month	☐ 3 years – 5 years
☐ 6 month – 3 year	☐ > 5 years

4. Shift work

☐ Yes ☐ No

5. How long do you working per day?

☐ < 5 hours	☐ 6 – 10 hours
☐ 11 – 15 hours	☐ >16 hours

6. How many days are you working per week?

☐ day/days

SECTION E: WORK ENVIRONMENT

Instruction: Please fill in the information below and tick (/) in a box given.

1. Is your workplace clean?

☐ Yes ☐ No

2. How many people work at your work section? ☐

3. Does the custodial team do a good job of housekeeping?

☐ Yes ☐ No

4. Is your workspace or area:

	Too humid		Excessive moisture
	Too hot		Mold growth
	Too dry		Too cold

SECTION F: DISEASE HISTORY

Instruction: In this section contain questions about family disease history and any other health problems. Please tick (/) in the box given. If you do not remember or not sure, please tick (/) in 'No' box.

1. Is there any of your family members parents or siblings being inform having those disease:

		1. Yes	**2. No**	**3. Do not Know**
i.	Chronic Bronchitis	☐	☐	☐
ii.	Emphysema	☐	☐	☐
iii.	Asthma	☐	☐	☐
iv.	Lung Cancer	☐	☐	☐
v.	Cardiovascular Disease	☐	☐	☐
vi.	Heart Attack	☐	☐	☐

2. Do you have history of disease as follow:

☐ Asthma
☐ Bronchitis
☐ Pneumonia
☐ Cardiovascular Disease
☐ Other health problem: _____

	Excellent	Good	Poor
3. What is your present health status?	☐	☐	☐

4. What health symptoms have you experienced:-

- Dry or sore throat ☐
- Dizziness ☐
- Dry, flaking skin ☐
- Skin irritation ☐
- Itching ☐
- Nausea ☐
- Sinus congestion ☐
- Sneezing ☐
- High stress levels ☐
- Chest tightness ☐
- Eye irritation ☐
- Fainting ☐
- Shortness of breath ☐
- Headache ☐
- Fatigue/drowsiness ☐
- Other (specify) ☐

5. When did the symptoms begin?

☐ < 6 month
☐ 6 month – 1 year
☐ 1years – 3 years
☐ > 3 years

APPENDIX 5

MSDS for Metalworking Fluids

SAFETY DATA SHEET

SECTION 1: Identification of the substance/mixture and of the company/undertaking

1.1 Product identifier

Product name	Solvent D 100
Product code	463151-DE03
SDS no.	463151
EC number	265-149-8
CAS number	64742-47-8
Product type	Liquid.

1.2 Relevant identified uses of the substance or mixture and uses advised against

Use of the substance/mixture	Hydrocarbon solvent. Neat Oil. For specific application advice see appropriate Technical Data Sheet or consult our company representative.

1.3 Details of the supplier of the safety data sheet

Supplier	Nordic Lubricants AB Castrol Industrial Lubricants and Services Box 49104 S-100 28 Stockholm Sweden Tel.: +46 (0)8-441 11 00 Fax.: +46 (0)8-651 01 35
E-mail address	MSDSadvice@bp.com

1.4 Emergency telephone number

EMERGENCY TELEPHONE NUMBER	Carechem: +44 (0) 208 762 8322 (24 hours)

SECTION 2: Hazards identification

2.1 Classification of the substance or mixture

Product definition Mono-constituent substance

Classification according to Regulation (EC) No. 1272/2008 [CLP/GHS]

Asp. Tox. 1, H304

Classification according to Directive 67/548/EEC [DSD]

Xn; R65
R66

See Section 16 for the full text of the R phrases or H statements declared above.

See sections 11 and 12 for more detailed information on health effects and symptoms and environmental hazards.

2.2 Label elements

Hazard pictograms

Signal word	Danger
Hazard statements	May be fatal if swallowed and enters airways.

Precautionary statements

Prevention	Not applicable.
Response	IF SWALLOWED: Immediately call a POISON CENTER or physician. Do NOT induce vomiting.
Storage	Store locked up.
Disposal	Not applicable.
Supplemental label elements	Repeated exposure may cause skin dryness or cracking.

Special packaging requirements

Containers to be fitted with child-resistant fastenings	Not applicable.
Tactile warning of danger	Not applicable.

2.3 Other hazards

Substance meets the criteria for PBT according to Regulation (EC) No. 1907/2006, Annex XIII	No.

SECTION 2: Hazards identification

Substance meets the criteria for vPvB according to Regulation (EC) No. 1907/2006, Annex XIII	No.
Other hazards which do not result in classification	Prolonged or repeated contact may dry skin and cause irritation.

SECTION 3: Composition/information on ingredients

Substance/mixture Mono-constituent substance

Hydrocarbon solvent

Product/ingredient name	Identifiers	%	Classification 67/548/EEC	Classification Regulation (EC) No. 1272/2008 [CLP]	Type
Kerosine - unspecified	EC: 265-149-8 CAS: 64742-47-8	100	Xn; R65 R66	Asp. Tox. 1, H304	[A]

See section 16 for the full text of the R-phrases declared above

See Section 16 for the full text of the H statements declared above.

Type

[A] Constituent
[B] Impurity
[C] Stabilising additive

Occupational exposure limits, if available, are listed in Section 8.

SECTION 4: First aid measures

4.1 Description of first aid measures

Eye contact	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Eyelids should be held away from the eyeball to ensure thorough rinsing. Check for and remove any contact lenses. Get medical attention.
Skin contact	Wash skin thoroughly with soap and water or use recognised skin cleanser. Remove contaminated clothing and shoes. Wash clothing before reuse. Clean shoes thoroughly before reuse. Get medical attention if irritation develops.
Inhalation	If inhaled, remove to fresh air. Get medical attention if symptoms appear.
Ingestion	Do not induce vomiting. Never give anything by mouth to an unconscious person. If unconscious, place in recovery position and get medical attention immediately. Aspiration hazard if swallowed. Can enter lungs and cause damage. Get medical attention immediately.
Protection of first-aiders	No action shall be taken involving any personal risk or without suitable training. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.

4.2 Most important symptoms and effects, both acute and delayed

See Section 11 for more detailed information on health effects and symptoms.

4.3 Indication of any immediate medical attention and special treatment needed

Notes to physician	Treatment should in general be symptomatic and directed to relieving any effects. Product can be aspirated on swallowing or following regurgitation of stomach contents, and can cause severe and potentially fatal chemical pneumonitis, which will require urgent treatment. Because of the risk of aspiration, induction of vomiting and gastric lavage should be avoided. Gastric lavage should be undertaken only after endotracheal intubation. Monitor for cardiac dysrhythmias.

SECTION 5: Firefighting measures

5.1 Extinguishing media

Suitable extinguishing media	In case of fire, use foam, dry chemical or carbon dioxide extinguisher or spray.
Unsuitable extinguishing media	Do not use water jet.

5.2 Special hazards arising from the substance or mixture

Hazards from the substance or mixture	In a fire or if heated, a pressure increase will occur and the container may burst.
Hazardous combustion products	Combustion products may include the following: carbon oxides (CO, CO_2) (carbon monoxide, carbon dioxide)

5.3 Advice for firefighters

Special precautions for fire-fighters	Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training.
Special protective equipment for fire-fighters	Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode. Clothing for fire-fighters (including helmets, protective boots and gloves) conforming to European standard EN 469 will provide a basic level of protection for chemical incidents.
Additional information	Not considered to be a product presenting a risk of explosion. Vapours may form explosive mixtures with air.

SECTION 6: Accidental release measures

6.1 Personal precautions, protective equipment and emergency procedures

For non-emergency personnel	No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilt material. Floors may be slippery; use care to avoid falling. Avoid breathing vapour or mist. Provide adequate ventilation. Put on appropriate personal protective equipment. Contact emergency personnel.
For emergency responders	Entry into a confined space or poorly ventilated area contaminated with vapour, mist or fume is extremely hazardous without the correct respiratory protective equipment and a safe system of work. Wear self-contained breathing apparatus. Wear a suitable chemical protective suit. Chemical resistant boots. See also the information in "For non-emergency personnel".
6.2 Environmental precautions	Avoid dispersal of spilt material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

6.3 Methods and materials for containment and cleaning up

Small spill	Stop leak if without risk. Move containers from spill area. Absorb with an inert material and place in an appropriate waste disposal container. Dispose of via a licensed waste disposal contractor.
Large spill	Stop leak if without risk. Move containers from spill area. Approach the release from upwind. Prevent entry into sewers, water courses, basements or confined areas. Contain and collect spillage with non-combustible, absorbent material e.g. sand, earth, vermiculite or diatomaceous earth and place in container for disposal according to local regulations. Contaminated absorbent material may pose the same hazard as the spilt product. Dispose of via a licensed waste disposal contractor.
6.4 Reference to other sections	See Section 1 for emergency contact information. See Section 5 for firefighting measures. See Section 8 for information on appropriate personal protective equipment. See Section 12 for environmental precautions. See Section 13 for additional waste treatment information.

SECTION 7: Handling and storage

7.1 Precautions for safe handling

Protective measures	Put on appropriate personal protective equipment (see Section 8). Do not swallow. Aspiration hazard Can enter lungs and cause damage. Never siphon by mouth. Avoid contact with eyes, skin and clothing. Avoid breathing vapour or mist. Keep in the original container or an approved alternative made from a compatible material, kept tightly closed when not in use. Do not reuse container. Empty containers retain product residue and can be hazardous.
Advice on general occupational hygiene	Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Wash thoroughly after handling. Remove contaminated clothing and protective equipment before entering eating areas. See also Section 8 for additional information on hygiene measures.
7.2 Conditions for safe storage, including any incompatibilities	Do not store above the following temperature: 50°C (122°F). Store in accordance with local regulations. Store in a dry, cool and well-ventilated area, away from incompatible materials (see Section 10). Store locked up. Keep container tightly closed and sealed until ready for use. Store and use only in equipment/containers designed for use with this product. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabelled containers. Keep away from heat and direct sunlight.

7.3 Specific end use(s)

Recommendations	See section 1.2 and Exposure scenarios in annex, if applicable.

SECTION 8: Exposure controls/personal protection

8.1 Control parameters

Occupational exposure limits

Product/ingredient name	Exposure limit values
Kerosine - unspecified	**AFS (Sweden).** KTV: 500 mg/m³ 15 minute(s). Form: decanes and other aliphatic hydrocarbons NGV: 350 mg/m³ 8 hour(s). Form: decanes and other aliphatic hydrocarbons
ACGIH TLVs	
Kerosine - unspecified	**ACGIH TLV (United States). Absorbed through skin.** TWA: 200 mg/m³ 8 hour(s). Issued/Revised: 1/2003

For information and guidance, the ACGIH values are included. For further information on these please consult your supplier.

Whilst specific OELs for certain components may be shown in this section, other components may be present in any mist, vapour or dust produced. Therefore, the specific OELs may not be applicable to the product as a whole and are provided for guidance only.

Recommended monitoring procedures	If this product contains ingredients with exposure limits, personal, workplace atmosphere or biological monitoring may be required to determine the effectiveness of the ventilation or other control measures and/or the necessity to use respiratory protective equipment. Reference should be made to European Standard EN 689 for methods for the assessment of exposure by inhalation to chemical agents and national guidance documents for methods for the determination of hazardous substances.

Derived No Effect Level

No DELs available.

Predicted No Effect Concentration

SECTION 8: Exposure controls/personal protection

No PNEC available.

8.2 Exposure controls

Appropriate engineering controls	Provide exhaust ventilation or other engineering controls to keep the relevant airborne concentrations below their respective occupational exposure limits. All activities involving chemicals should be assessed for their risks to health, to ensure exposures are adequately controlled. Personal protective equipment should only be considered after other forms of control measures (e.g. engineering controls) have been suitably evaluated. Personal protective equipment should conform to appropriate standards, be suitable for use, be kept in good condition and properly maintained. Your supplier of personal protective equipment should be consulted for advice on selection and appropriate standards. For further information contact your national organisation for standards. The final choice of protective equipment will depend upon a risk assessment. It is important to ensure that all items of personal protective equipment are compatible.

Individual protection measures

Hygiene measures	Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Ensure that eyewash stations and safety showers are close to the workstation location.
Respiratory protection	Use a properly fitted, air-purifying or air-fed respirator complying with an approved standard if a risk assessment indicates this is necessary. The correct choice of respiratory protection depends upon the chemicals being handled, the conditions of work and use, and the condition of the respiratory equipment. Safety procedures should be developed for each intended application. Respiratory protection equipment should therefore be chosen in consultation with the supplier/manufacturer and with a full assessment of the working conditions.
Eye/face protection	Safety glasses with side shields.

Skin protection

Hand protection	Wear suitable gloves. The correct choice of protective gloves depends upon the chemicals being handled, the conditions of work and use, and the condition of the gloves (even the best chemically resistant glove will break down after repeated chemical exposures). Most gloves provide only a short time of protection before they must be discarded and replaced. Because specific work environments and material handling practices vary, safety procedures should be developed for each intended application. Gloves should therefore be chosen in consultation with the supplier/manufacturer and with a full assessment of the working conditions.
Skin and body	Use of protective clothing is good industrial practice. Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product. Cotton or polyester/cotton overalls will only provide protection against light superficial contamination that will not soak through to the skin. Overalls should be laundered on a regular basis. When the risk of skin exposure is high (e.g. when cleaning up spillages or if there is a risk of splashing) then chemical resistant aprons and/or impervious chemical suits and boots will be required.
Environmental exposure controls	Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

SECTION 9: Physical and chemical properties

9.1 Information on basic physical and chemical properties

Appearance	
Physical state	Liquid.
Colour	Colourless.
Odour	Hydrocarbon.
Odour threshold	Not available.
pH	Not available.
Melting point/freezing point	Not available.
Initial boiling point and boiling range	230°C (446°F)
Flash point	Closed cup: >101°C (>213.8°F) [Pensky-Martens.]
Evaporation rate	Not available.
Flammability (solid, gas)	Not available.
Upper/lower flammability or explosive limits	Lower: 0.6% Upper: 7%
Vapour pressure	<0.01 kPa (<0.075 mm Hg) at 20°C
Vapour density	Not available.
Relative density	Not available.
Density	<1000 kg/m^3 (<1 g/cm^3) at 20°C
Solubility(ies)	insoluble in water.
Partition coefficient: n-octanol/water	Not available.
Auto-ignition temperature	>230°C (>446°F)
Decomposition temperature	Not available.
Viscosity	Kinematic: <3 mm^2/s (<3 cSt) at 40°C Kinematic: 3.5 mm^2/s (3.5 cSt) at 20°C

SECTION 9: Physical and chemical properties

Explosive properties	Not considered to be a product presenting a risk of explosion. Vapours may form explosive mixtures with air.
Oxidising properties	Not available.

9.2 Other information

No additional information.

SECTION 10: Stability and reactivity

10.1 Reactivity	No specific test data available for this product. Refer to Conditions to avoid and Incompatible materials for additional information.
10.2 Chemical stability	The product is stable.
10.3 Possibility of hazardous reactions	Under normal conditions of storage and use, hazardous reactions will not occur. Under normal conditions of storage and use, hazardous polymerisation will not occur.
10.4 Conditions to avoid	High temperatures
10.5 Incompatible materials	Reactive or incompatible with the following materials: oxidising materials.
10.6 Hazardous decomposition products	Under normal conditions of storage and use, hazardous decomposition products should not be produced.

SECTION 11: Toxicological information

11.1 Information on toxicological effects

Aspiration hazard

Product/ingredient name	Result
Kerosine - unspecified	ASPIRATION HAZARD - Category 1

Conclusion/Summary	May be fatal if swallowed and enters airways. Classification on basis substance is a hydrocarbon and has a kinematic viscosity of 20.5 mm2/s or less, measured at 40°C.

Specific target organ toxicity

Information on the likely routes of exposure	Routes of entry anticipated:Oral, Dermal, Inhalation.

Potential acute health effects

Inhalation	Vapour inhalation under ambient conditions is not normally a problem due to low vapour pressure.
Ingestion	Aspiration hazard if swallowed -- harmful or fatal if liquid is aspirated into lungs.
Skin contact	No known significant effects or critical hazards.
Eye contact	No known significant effects or critical hazards.

Symptoms related to the physical, chemical and toxicological characteristics

Inhalation	No specific data.
Ingestion	Adverse symptoms may include the following: nausea or vomiting
Skin contact	Adverse symptoms may include the following: irritation dryness cracking
Eye contact	No specific data.

Delayed and immediate effects and also chronic effects from short and long term exposure

Inhalation	Overexposure to the inhalation of airborne droplets or aerosols may cause irritation of the respiratory tract.
Ingestion	Ingestion of large quantities may cause nausea and diarrhea.
Skin contact	Prolonged or repeated contact can defat the skin and lead to irritation and/or dermatitis.
Eye contact	Potential risk of transient stinging or redness if accidental eye contact occurs.

Potential chronic health effects

General	Prolonged or repeated contact can defat the skin and lead to irritation, cracking and/or dermatitis.
Carcinogenicity	No known significant effects or critical hazards.
Mutagenicity	No known significant effects or critical hazards.
Developmental effects	No known significant effects or critical hazards.
Fertility effects	No known significant effects or critical hazards.

SECTION 12: Ecological information

12.1 Toxicity

Environmental hazards	Not classified as dangerous

12.2 Persistence and degradability

Inherently biodegradable

12.3 Bioaccumulative potential

This product may bioaccumulate through food chains in the environment.

SECTION 12: Ecological information

12.4 Mobility in soil

Soil/water partition coefficient (K_{OC})	Not available.
Mobility	Non-volatile. Liquid. insoluble in water.

12.5 Results of PBT and vPvB assessment

PBT	No.
vPvB	No.

12.6 Other adverse effects: No known significant effects or critical hazards.

SECTION 13: Disposal considerations

13.1 Waste treatment methods

Product

Methods of disposal: The generation of waste should be avoided or minimised wherever possible. Significant quantities of waste product residues should not be disposed of via the foul sewer but processed in a suitable effluent treatment plant. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements.

Hazardous waste: Yes.

European waste catalogue (EWC)

Waste code	Waste designation
13 08 99*	wastes not otherwise specified

However, deviation from the intended use and/or the presence of any potential contaminants may require an alternative waste disposal code to be assigned by the end user.

Packaging

Methods of disposal: Where possible, arrange for product to be recycled. Dispose of via an authorised person/ licensed waste disposal contractor in accordance with local regulations.

Type of packaging	European waste catalogue (EWC)	
Steel drum	15 01 10*	packaging containing residues of or contaminated by dangerous substances

Special precautions: This material and its container must be disposed of in a safe way. Care should be taken when handling emptied containers that have not been cleaned or rinsed out. Empty containers or liners may retain some product residues. Empty containers represent a fire hazard as they may contain flammable product residues and vapour. Never weld, solder or braze empty containers. Avoid dispersal of spilt material and runoff and contact with soil, waterways, drains and sewers.

Methods of disposal: The regulations regarding manufacturers' responsibility for packaging material waste is regulated in "Förordningen om producentansvar för förpackningar". Packaging materials are to be reused or recycled in accordance with the goals outlined in this regulation. The company complies with this manufacturer's responsibility through its association with REPA, which is a subsidiary company of four materials handling companies. The materials handling companies collect, remove and process used and sorted packaging materials through the employment of contractors. Questions regarding collection of packaging materials on a local basis may be directed to the materials company and its contractors. For further information, contact REPA, www.repa.se.

SECTION 14: Transport information

	ADR/RID	ADN/ADNR	IMDG	IATA
14.1 UN number	Not regulated.	Not regulated.	Not regulated.	Not regulated.
14.2 UN proper shipping name	-	-	-	-
14.3 Transport hazard class(es)	-	-	-	-
14.4 Packing group	-	-	-	-
14.5 Environmental hazards	No.	No.	No.	No.
14.6 Special precautions for user	Not available.	Not available.	Not available.	Not available.
Additional information	-	-	-	-

SECTION 15: Regulatory information

15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture

EU Regulation (EC) No. 1907/2006 (REACH)

Annex XIV - List of substances subject to authorisation

Substances of very high concern

None of the components are listed.

Annex XVII - Restrictions on the manufacture, placing on the market and use of certain dangerous substances, mixtures and articles	Not applicable.

Other regulations

United States inventory (TSCA 8b)	All components are listed or exempted.
Australia inventory (AICS)	All components are listed or exempted.
Canada inventory	All components are listed or exempted.
China inventory (IECSC)	All components are listed or exempted.
Japan inventory (ENCS)	All components are listed or exempted.
Korea inventory (KECI)	All components are listed or exempted.
Philippines inventory (PICCS)	All components are listed or exempted.

15.2 Chemical Safety Assessment	This product contains substances for which Chemical Safety Assessments are still required.

SECTION 16: Other information

Abbreviations and acronyms

ADN/ADNR = European Provisions concerning the International Carriage of Dangerous Goods by Inland Waterway
ADR = The European Agreement concerning the International Carriage of Dangerous Goods by Road
ATE = Acute Toxicity Estimate
BCF = Bioconcentration Factor
CAS = Chemical Abstracts Service
CLP = Classification, Labelling and Packaging Regulation [Regulation (EC) No. 1272/2008]
CSA = Chemical Safety Assessment
CSR = Chemical Safety Report
DMEL = Derived Minimal Effect Level
DNEL = Derived No Effect Level
DPD = Dangerous Preparations Directive [1999/45/EC]
DSD = Dangerous Substances Directive [67/548/EEC]
EINECS = European Inventory of Existing Commercial chemical Substances
ES = Exposure Scenario
EUH statement = CLP-specific Hazard statement
EWC = European Waste Catalogue
GHS = Globally Harmonized System of Classification and Labelling of Chemicals
IATA = International Air Transport Association
IBC = Intermediate Bulk Container
IMDG = International Maritime Dangerous Goods
LogPow = logarithm of the octanol/water partition coefficient
MARPOL 73/78 = International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" = marine pollution)
OECD = Organisation for Economic Co-operation and Development
PBT = Persistent, Bioaccumulative and Toxic
PNEC = Predicted No Effect Concentration
RID = The Regulations concerning the International Carriage of Dangerous Goods by Rail
RRN = REACH Registration Number
SADT = Self-Accelerating Decomposition Temperature
SVHC = Substances of Very High Concern
STOT-RE = Specific Target Organ Toxicity - Repeated Exposure
STOT-SE = Specific Target Organ Toxicity - Single Exposure
UN = United Nations
UVCB = Complex hydrocarbon substance
VOC = Volatile Organic Compound
vPvB = Very Persistent and Very Bioaccumulative

Full text of abbreviated H statements	H304 May be fatal if swallowed and enters airways.
Full text of classifications [CLP/GHS]	Asp. Tox. 1, H304 ASPIRATION HAZARD - Category 1
Full text of abbreviated R phrases	R65- Harmful: may cause lung damage if swallowed. R66- Repeated exposure may cause skin dryness or cracking.
Full text of classifications [DSD/DPD]	Xn - Harmful

History

Date of issue/ Date of revision	12/11/2010.
Date of previous issue	No previous validation.
Prepared by	Product Stewardship

▽ **Indicates information that has changed from previously issued version.**

Notice to reader

SECTION 16: Other information

All reasonably practicable steps have been taken to ensure this data sheet and the health, safety and environmental information contained in it is accurate as of the date specified below. No warranty or representation, express or implied is made as to the accuracy or completeness of the data and information in this data sheet.

The data and advice given apply when the product is sold for the stated application or applications. You should not use the product other than for the stated application or applications without seeking advice from us.

It is the user's obligation to evaluate and use this product safely and to comply with all applicable laws and regulations. The BP Group shall not be responsible for any damage or injury resulting from use, other than the stated product use of the material, from any failure to adhere to recommendations, or from any hazards inherent in the nature of the material. Purchasers of the product for supply to a third party for use at work, have a duty to take all necessary steps to ensure that any person handling or using the product is provided with the information in this sheet. Employers have a duty to tell employees and others who may be affected of any hazards described in this sheet and of any precautions that should be taken.

SAFETY DATA SHEET

Rustilo DWX 88 IV

Section 1. Identification

GHS product identifier	Rustilo DWX 88 IV
Product code	465017-TH04
SDS no.	465017

Relevant identified uses of the substance or mixture and uses advised against

Use of the substance/ mixture	Rust preventive / Water displacement fluid For specific application advice see appropriate Technical Data Sheet or consult our company representative.
Manufacturer	
Supplier	BP-Castrol (Thailand) Limited Samut Sakon Industrial Estate, 39/77-78 Moo 2 Rama II Road, Bangkachao Amphur Muang, Samut Sakorn 74000 Tel. +66 34 419666, Fax. +66 34 419666
EMERGENCY TELEPHONE NUMBER	Carechem: 001800 1 2066 6751 (tollfree, access from Thailand only)
OTHER PRODUCT INFORMATION	Please contact at Technical Service Section Tel no.+662-684-3430

Section 2. Hazards identification

GHS Classification

FLAMMABLE LIQUIDS - Category 3
SKIN CORROSION/IRRITATION - Category 3
ASPIRATION HAZARD - Category 1

GHS label elements

Hazard pictograms

Signal word

Danger

Hazard statements

H226 - Flammable liquid and vapour.
H316 - Causes mild skin irritation.
H304 - May be fatal if swallowed and enters airways.

Precautionary statements

Prevention

P280 - Wear protective gloves. Wear eye or face protection.
P210 - Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking.
P241 - Use explosion-proof electrical, ventilating, lighting and all material-handling equipment.
P242 - Use only non-sparking tools.
P243 - Take precautionary measures against static discharge.
P233 - Keep container tightly closed.

Response

P301 + P310 + P331 - IF SWALLOWED: Immediately call a POISON CENTER or physician. Do NOT induce vomiting.
P303 + P361 + P353 - IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water or shower.
P332 + P313 - If skin irritation occurs: Get medical attention.

Storage

P405 - Store locked up.
P403 - Store in a well-ventilated place.
P235 - Keep cool.

Disposal

P501 - Dispose of contents and container in accordance with all local, regional, national and international regulations.

Other hazards which do not result in classification

Defatting to the skin.

Section 3. Composition/information on ingredients

Substance/mixture Mixture

Hydrocarbon solvent, film forming corrosion preventives and additives

Ingredient name	%	CAS number
Low boiling point hydrogen treated naphtha	50-100	64742-48-9
Base oil - unspecified	10-20	Varies
2-Butoxyethanol	1-5	111-76-2

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First-aid measures

Description of necessary first aid measures

Inhalation If inhaled, remove to fresh air. Get medical attention if symptoms occur.

Ingestion Do not induce vomiting. Never give anything by mouth to an unconscious person. If unconscious, place in recovery position and get medical attention immediately. Aspiration hazard if swallowed. Can enter lungs and cause damage. Get medical attention immediately.

Skin contact In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash skin thoroughly with soap and water or use recognised skin cleanser. Wash clothing before reuse. Clean shoes thoroughly before reuse. Get medical attention if symptoms occur.

Eye contact In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Eyelids should be held away from the eyeball to ensure thorough rinsing. Check for and remove any contact lenses. Get medical attention.

Most important symptoms/effects, acute and delayed

See Section 11 for more detailed information on health effects and symptoms.

Indication of immediate medical attention and special treatment needed, if necessary

Specific treatments No specific treatment.

Notes to physician Treatment should in general be symptomatic and directed to relieving any effects. Product can be aspirated on swallowing or following regurgitation of stomach contents, and can cause severe and potentially fatal chemical pneumonitis, which will require urgent treatment. Because of the risk of aspiration, induction of vomiting and gastric lavage should be avoided. Gastric lavage should be undertaken only after endotracheal intubation. Monitor for cardiac dysrhythmias.

Protection of first-aiders No action shall be taken involving any personal risk or without suitable training. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.

Section 5. Fire-fighting measures

Extinguishing media

Suitable extinguishing media Use dry chemical, CO_2, water spray (fog) or foam.

Unsuitable extinguishing media Do not use water jet.

Specific hazards arising from the chemical Flammable liquid and vapour. In a fire or if heated, a pressure increase will occur and the container may burst, with the risk of a subsequent explosion. Runoff to sewer may create fire or explosion hazard.

Hazardous thermal decomposition products Combustion products may include the following:
carbon dioxide
carbon monoxide
metal oxide/oxides

Special protective actions for fire-fighters Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Move containers from fire area if this can be done without risk. Use water spray to keep fire-exposed containers cool.

Special protective equipment for fire-fighters Fire-fighters should wear positive pressure self-contained breathing apparatus (SCBA) and full turnout gear. Fire-fighters' protective clothing will only provide limited protection.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

For non-emergency personnel

Immediately contact emergency personnel. No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilt material. No flares, smoking or flames in hazard area. Avoid breathing vapour or mist. Provide adequate ventilation. Put on appropriate personal protective equipment. Floors may be slippery; use care to avoid falling. Eliminate all ignition sources.

For emergency responders

Entry into a confined space or poorly ventilated area contaminated with vapour, mist or fume is extremely hazardous without the correct respiratory protective equipment and a safe system of work. Wear self-contained breathing apparatus. Wear a suitable chemical protective suit. Chemical resistant boots. See also the information in "For non-emergency personnel".

Environmental precautions

Avoid dispersal of spilt material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods and materials for containment and cleaning up

Small spill

Stop leak if without risk. Move containers from spill area. Absorb with an inert material and place in an appropriate waste disposal container. Use spark-proof tools and explosion-proof equipment. Dispose of via a licensed waste disposal contractor. The method and equipment used must be in conformance with appropriate regulations and industry practice on explosive atmospheres.

Large spill

Stop leak if without risk. Move containers from spill area. Approach the release from upwind. Prevent entry into sewers, water courses, basements or confined areas. Contain and collect spillage with non-combustible, absorbent material e.g. sand, earth, vermiculite or diatomaceous earth and place in container for disposal according to local regulations. Use spark-proof tools and explosion-proof equipment. Contaminated absorbent material may pose the same hazard as the spilt product. The method and equipment used must be in conformance with appropriate regulations and industry practice on explosive atmospheres. Dispose of via a licensed waste disposal contractor.

Section 7. Handling and storage

Precautions for safe handling

Protective measures

Put on appropriate personal protective equipment (see Section 8). Avoid breathing vapour or mist. Use only with adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Take precautionary measures against electrostatic discharges. To avoid fire or explosion, dissipate static electricity during transfer by earthing and bonding containers and equipment before transferring material. Avoid contact with eyes, skin and clothing. Empty containers retain product residue and can be hazardous. Keep in the original container or an approved alternative made from a compatible material, kept tightly closed when not in use. Do not reuse container. Store and use away from heat, sparks, open flame or any other ignition source. Use explosion-proof electrical (ventilating, lighting and material handling) equipment. Use only non-sparking tools. Do not swallow. Aspiration hazard if swallowed. Can enter lungs and cause damage. Never siphon by mouth. Avoid prolonged or repeated contact with skin. During metal working, solid particles from workpieces or tools will contaminate the fluid and may cause abrasions of the skin. Where such abrasions result in a penetration of the skin, first aid treatment should be applied as soon as reasonably possible. The presence of certain metals in the workpiece or tool, such as chromium, cobalt and nickel, can contaminate the metalworking fluid and as a result may induce allergic skin reactions. Keep away from ignition sources such as heat/sparks/open flame. - No smoking. Concentrations of mist, fumes and vapours in enclosed spaces may result in the formation of explosive atmospheres. Excessive splashing, agitation or heating must be avoided.

Advice on general occupational hygiene

Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Wash thoroughly after handling. Remove contaminated clothing and protective equipment before entering eating areas. See also Section 8 for additional information on hygiene measures.

Section 7. Handling and storage

Conditions for safe storage, including any incompatibilities

Store in accordance with local regulations. Store in a segregated and approved area. Store in original container protected from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see Section 10) and food and drink. Store locked up. Eliminate all ignition sources. Separate from oxidising materials. Keep container tightly closed and sealed until ready for use. Store and use only in equipment/containers designed for use with this product. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabelled containers. Use appropriate containment to avoid environmental contamination.

Section 8. Exposure controls/personal protection

Control parameters

Occupational exposure limits

Ingredient name	Exposure limits
Low boiling point hydrogen treated naphtha	**ACGIH TLV (United States).** TWA: 300 ppm
Base oil - unspecified	**ACGIH TLV (United States).** TWA: 5 mg/m³ 8 hours. Issued/Revised: 11/2009 Form: Inhalable fraction
2-Butoxyethanol	**ACGIH TLV (United States).** TWA: 20 ppm 8 hours. Issued/Revised: 1/2003

Appropriate engineering controls

All activities involving chemicals should be assessed for their risks to health, to ensure exposures are adequately controlled. Personal protective equipment should only be considered after other forms of control measures (e.g. engineering controls) have been suitably evaluated. Personal protective equipment should conform to appropriate standards, be suitable for use, be kept in good condition and properly maintained.
Your supplier of personal protective equipment should be consulted for advice on selection and appropriate standards. For further information contact your national organisation for standards.
Provide exhaust ventilation or other engineering controls to keep the relevant airborne concentrations below their respective occupational exposure limits.
The final choice of protective equipment will depend upon a risk assessment. It is important to ensure that all items of personal protective equipment are compatible.

Environmental exposure controls

Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Eye protection

Safety glasses with side shields.

Skin protection

Hand protection

Wear chemical resistant gloves. Recommended: Nitrile gloves. The correct choice of protective gloves depends upon the chemicals being handled, the conditions of work and use, and the condition of the gloves (even the best chemically resistant glove will break down after repeated chemical exposures). Most gloves provide only a short time of protection before they must be discarded and replaced. Because specific work environments and material handling practices vary, safety procedures should be developed for each intended application. Gloves should therefore be chosen in consultation with the supplier/manufacturer and with a full assessment of the working conditions.

Skin protection

Use of protective clothing is good industrial practice. Wear clothing and footwear that cannot be penetrated by chemicals or oil. Cotton or polyester/cotton overalls will only provide protection against light superficial contamination that will not soak through to the skin. Overalls should be laundered on a regular basis. When the risk of skin exposure is high (e.g. when cleaning up spillages or if there is a risk of splashing) then chemical resistant aprons and/or impervious chemical suits and boots will be required. Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Section 8. Exposure controls/personal protection

Respiratory protection	Use with adequate ventilation. In case of insufficient ventilation, wear suitable respiratory equipment. Recommended: half-face mask - organic vapor filter (Type A). The correct choice of respiratory protection depends upon the chemicals being handled, the conditions of work and use, and the condition of the respiratory equipment. Safety procedures should be developed for each intended application. Respiratory protection equipment should therefore be chosen in consultation with the supplier/manufacturer and with a full assessment of the working conditions.

Section 9. Physical and chemical properties

Appearance

Physical state	Liquid.
Colour	Clear Brown. [Light]
Odour	Solvent.
Odour threshold	Not available.
pH	Not available.
Melting point	Not available.
Boiling point	Not available.
Drop Point	Not available.
Flash point	Closed cup: 60°C (140°F) [Pensky-Martens.]
Evaporation rate	Not available.
Flammability (solid, gas)	Not applicable. Based on - Physical state
Lower and upper explosive (flammable) limits	Not available.
Vapour pressure	Not available.
Vapour density	Not available.
Relative density	Not available.
Density	<1000 kg/m³ (<1 g/cm³) at 30°C
Solubility	insoluble in water.
Partition coefficient: n-octanol/water	Not available.
Auto-ignition temperature	Not available.
Decomposition temperature	Not available.
Viscosity	Kinematic: <2 mm²/s (<2 cSt) at 40°C

Section 10. Stability and reactivity

Reactivity	No specific test data available for this product. Refer to Conditions to avoid and Incompatible materials for additional information.
Chemical stability	The product is stable.
Possibility of hazardous reactions	Under normal conditions of storage and use, hazardous reactions will not occur. Under normal conditions of storage and use, hazardous polymerisation will not occur.
Conditions to avoid	Avoid all possible sources of ignition (spark or flame). Avoid excessive heat. Do not pressurise, cut, weld, braze, solder, drill, grind or expose containers to heat or sources of ignition.
Incompatible materials	Reactive or incompatible with the following materials: oxidising materials.
Hazardous decomposition products	Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Section 11. Toxicological information

Information on toxicological effects

Aspiration hazard

Name	Result
Low boiling point hydrogen treated naphtha	ASPIRATION HAZARD - Category 1

Section 11. Toxicological information

Information on the likely routes of exposure Routes of entry anticipated: Dermal, Inhalation.

Potential acute health effects

Eye contact Causes eye irritation.

Inhalation Vapour inhalation under ambient conditions is not normally a problem due to low vapour pressure.

Skin contact Causes mild skin irritation. Defatting to the skin.

Ingestion Irritating to mouth, throat and stomach. Aspiration hazard if swallowed -- harmful or fatal if liquid is aspirated into lungs. Ingestion of large quantities may cause nausea and diarrhoea.

Symptoms related to the physical, chemical and toxicological characteristics

Eye contact Adverse symptoms may include the following:
pain or irritation
watering
redness

Inhalation Exposure to high concentrations can cause dizziness, lightheadedness, headache, nausea and blurred vision. Higher levels may cause unconsciousness.
May be harmful by inhalation if exposure to vapour, mists or fumes resulting from thermal decomposition products occurs.

Skin contact Adverse symptoms may include the following:
irritation
redness
dryness
cracking

Ingestion Adverse symptoms may include the following:
nausea or vomiting

Delayed and immediate effects and also chronic effects from short and long term exposure

Inhalation Overexposure to the inhalation of airborne droplets or aerosols may cause irritation of the respiratory tract.

Potential chronic health effects

General No known significant effects or critical hazards.

Carcinogenicity No known significant effects or critical hazards.

Mutagenicity No known significant effects or critical hazards.

Teratogenicity No known significant effects or critical hazards.

Developmental effects No known significant effects or critical hazards.

Fertility effects No known significant effects or critical hazards.

Numerical measures of toxicity

Acute toxicity estimates

Route	ATE value
Oral	16666.7 mg/kg
Dermal	36666.7 mg/kg
Inhalation (vapours)	366.7 mg/l

Section 12. Ecological information

Environmental effects No known significant effects or critical hazards.

Persistence and degradability

Expected to be biodegradable.

Bioaccumulative potential

Not available.

Mobility Volatile. Liquid. insoluble in water.

Other adverse effects No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods

The generation of waste should be avoided or minimised wherever possible. Significant quantities of waste product residues should not be disposed of via the foul sewer but processed in a suitable effluent treatment plant. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Care should be taken when handling emptied containers that have not been cleaned or rinsed out. Empty containers or liners may retain some product residues. Vapor from product residues may create a highly flammable or explosive atmosphere inside the container. Do not cut, weld or grind used containers unless they have been cleaned thoroughly internally. Avoid dispersal of spilt material and runoff and contact with soil, waterways, drains and sewers.

Section 14. Transport information

	IMDG	IATA
UN number	UN1993	UN1993
UN proper shipping name	FLAMMABLE LIQUID, N.O.S. (Low boiling point hydrogen treated naphtha)	FLAMMABLE LIQUID, N.O.S. (Low boiling point hydrogen treated naphtha)
Transport hazard class(es)	3 	3 
Packing group	III	III
Environmental hazards	No.	No.
Additional information	Emergency schedules (EmS) F-E, S-E	

Special precautions for user Not available.

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code Not available.

Section 15. Regulatory information

Regulation according to other foreign laws

Australia inventory (AICS)	At least one component is not listed.
Canada inventory status	At least one component is not listed.
China inventory (IECSC)	At least one component is not listed.
REACH Status	For the REACH status of this product please consult your company contact, as identified in Section 1.
Japan inventory (ENCS)	At least one component is not listed.
Korea inventory (KECI)	At least one component is not listed.
Philippines inventory (PICCS)	Not determined.
United States inventory (TSCA 8b)	At least one component is not listed.
Thailand - Harmful Chemicals List I	Listed

Section 16. Other information

History

Date of issue/Date of revision	05/02/2014.
Date of previous issue	17/07/2013.
Prepared by	Product Stewardship
References	Not available.

Indicates information that has changed from previously issued version.

Notice to reader

All reasonably practicable steps have been taken to ensure this data sheet and the health, safety and environmental information contained in it is accurate as of the date specified below. No warranty or representation, express or implied is made as to the accuracy or completeness of the data and information in this data sheet.

The data and advice given apply when the product is sold for the stated application or applications. You should not use the product other than for the stated application or applications without seeking advice from BP Group.

It is the user's obligation to evaluate and use this product safely and to comply with all applicable laws and regulations. The BP Group shall not be responsible for any damage or injury resulting from use, other than the stated product use of the material, from any failure to adhere to recommendations, or from any hazards inherent in the nature of the material. Purchasers of the product for supply to a third party for use at work, have a duty to take all necessary steps to ensure that any person handling or using the product is provided with the information in this sheet. Employers have a duty to tell employees and others who may be affected of any hazards described in this sheet and of any precautions that should be taken. You can contact the BP Group to ensure that this document is the most current available. Alteration of this document is strictly prohibited.

Material Safety Data Sheet

1. Chemical product and company identification

Product name	CASTROL HYSPIN AW 68
MSDS#	12017-AE
Code	12017-AE
Product use	Lubricant
Manufacturer	CASTROL INDUSTRIAL NORTH AMERICA INC. 1001 WEST 31ST STREET DOWNERS GROVE, IL 60515-1280 TEL.: 1 - 630-241-4000 (USA)
Supplier	CASTROL INDUSTRIAL NORTH AMERICA INC. 1001 West 31St Street Downers Grove, IL 60515-1280 U.S.A. 1 (630) 241-4000 (USA)
EMERGENCY SPILL INFORMATION:	1 (800) 424-9300 CHEMTREC (USA)

2. Composition/information on ingredients

Ingredient name	CAS #	% by weight	Exposure limits
Distillates (petroleum), solvent-refined heavy paraffinic	64741-88-4	95-100	**ACGIH (United States).** TWA: 5 mg/m³ 8 hour(s). Form: Mist STEL: 10 mg/m³ 15 minute(s). Form: Mist **OSHA (United States).** TWA: 5 mg/m³ 8 hour(s). Form: Mist

3. Hazards identification

Physical state	Liquid.
Color	Clear. Yellow. Color
Emergency overview	CAUTION! MAY CAUSE EYE IRRITATION. MAY CAUSE SKIN IRRITATION. MAY CAUSE RESPIRATORY TRACT IRRITATION. Avoid prolonged or repeated contact with skin. Keep container closed. Wash thoroughly after handling. Prolonged or repeated contact can defat the skin and lead to irritation and/or dermatitis. Use with adequate ventilation. In accordance with good industrial hygiene and safety work practices, airborne exposures should be controlled to the lowest extent practicable.
Routes of entry	Dermal contact. Eye contact. Inhalation. Ingestion.
Potential Health Effects	
Eyes	May cause eye irritation.

Skin	May cause skin irritation. Prolonged or repeated contact can defat the skin and lead to irritation and/or dermatitis.
Inhalation	May cause respiratory tract irritation.
Ingestion	Ingestion may cause gastrointestinal irritation and diarrhea.
Medical conditions aggravated by overexposure:	None identified.

See toxicological Information (section 11)

4. First aid measures

Eye Contact	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention if irritation develops.
Skin Contact	Immediately wash exposed skin with soap and water. Remove contaminated clothing and shoes. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention if irritation develops.
Inhalation	If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.
Ingestion	Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Get medical attention if symptoms appear.

5. Fire-fighting measures

Flammability of the product	May be combustible at high temperature.
Flash point	226 °C (Open cup) Cleveland.
Products of combustion	These products are carbon oxides (CO, CO_2).
Unusual fire/explosion hazards	This material is not explosive as defined by established regulatory criteria. Non-explosive in presence of open flames, sparks and static discharge, of shocks, of heat, of oxidizing materials.
Fire fighting media and instructions	In case of fire, use water fog, foam, dry chemicals, or carbon dioxide.
Protective clothing (fire)	Fire-fighters should wear positive pressure self-contained breathing apparatus (SCBA) and full turnout gear.

6. Accidental release measures

Personal Precautions	Immediately contact emergency personnel. Keep unnecessary personnel away. Use suitable protective equipment (Section 8). Follow all fire fighting procedures (Section 5).
Environmental precautions and clean-up methods	If emergency personnel are unavailable, contain spilled material. For small spills add absorbent (soil may be used in the absence of other suitable materials) scoop up material and place in a sealed, liquid-proof container for disposal. For large spills dike spilled material or otherwise contain material to ensure runoff does not reach a waterway. Place spilled material in an appropriate container for disposal. Minimize contact of spilled material with soils to prevent runoff to surface waterways. See Section 13 for Waste Disposal Information.
Personal protection in case of a large spill	Splash goggles. Full suit. Boots. Gloves. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

7. Handling and storage

Handling Avoid prolonged or repeated contact with skin. Avoid contact with eyes. Use only with adequate ventilation. Wash thoroughly after handling. In accordance with good industrial hygiene and safety work practices, airborne exposures should be controlled to the lowest extent practicable.

Storage Keep container tightly closed. Keep container in a cool, well-ventilated area. Empty containers may contain harmful, flammable/combustible or explosive residue or vapors. Do not cut, grind, drill, weld, reuse or dispose of containers unless adequate precautions are taken against these hazards.

8. Exposure controls/personal protection

Occupational exposure limits

Ingredient name	Occupational exposure limits
Distillates (petroleum), solvent-refined heavy paraffinic	**ACGIH (United States).** TWA: 5 mg/m³ 8 hour(s). Form: Mist STEL: 10 mg/m³ 15 minute(s). Form: Mist **OSHA (United States).** TWA: 5 mg/m³ 8 hour(s). Form: Mist

Control Measures Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective occupational exposure limits.

Hygiene measures Wash hands after handling compounds and before eating, smoking, using lavatory, and at the end of day.

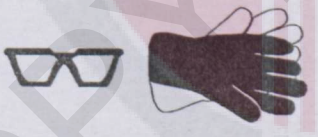
Personal protection

Eyes Avoid contact with eyes. Safety glasses with side shield or chemical goggles.

Skin and Body Avoid prolonged or repeated contact with skin. Wear suitable protective clothing.

Respiratory Use only with adequate ventilation.

Hands Wear suitable gloves.



Consult local authorities for acceptable exposure limits.

9. Physical and chemical properties

Physical state	Liquid.
pH	Not applicable
Odor	Oily Odor (Slight.)
Color	Clear. Yellow. Color
Specific Gravity	0.89
Density	890 kg/m³ (0.89 g/cm³) at 15.6°C
Solubility	Insoluble in cold water, hot water.

Viscosity	Kinematic: 61.2 to 74.8 mm^2/s (61.2 to 74.8 cSt) at 40°C

10. Stability and reactivity

Stability and Reactivity	The product is stable.
Conditions to avoid	None known.
Incompatibility with various substances	Reactive with oxidizing agents.
Hazardous Decomposition Products	Carbon Dioxide (CO_2). nitrogen oxides (NO, NO_2...)
Hazardous polymerization	Will not occur.

11. Toxicological information

Chronic toxicity

Carcinogenic effects	No component of this product at levels greater than 0.1% is identified as a carcinogen by ACGIH or the International Agency for Research on Cancer (IARC). No component of this product present at levels greater than 0.1% is identified as a carcinogen by the U.S. National Toxicology Program (NTP) or the U.S. Occupational Safety and Health Act (OSHA).
Mutagenic effects	No component of this product at levels greater than 0.1% is classified by established regulatory criteria as a mutagen.
Reproductive effects	No component of this product at levels greater than 0.1% is classified by established regulatory criteria as a reproductive toxin.
Teratogenic effects	No component of this product at levels greater than 0.1% is classified by established regulatory criteria as teratogenic or embryotoxic.

12. Ecological information

Ecotoxicity	No testing has been performed by the manufacturer.

13. Disposal considerations

Waste information	Waste must be disposed of in accordance with federal, state and local environmental control regulations.
RCRA Waste Code(s)	USED OIL

Consult your local or regional authorities.

14. Transport information

International transport regulations

Regulatory Information	UN number	Proper shipping name	Class	Packing group	Label	Additional information
DOT Classification	Not regulated.	Not available.	Not available.	Not available.		Not available.
TDG Classification	Not regulated.	-----	-----	Not available.		Not available.
IMDG Classification	Not available.	Not available.	Not available.	Not available.		Not available.
IATA Classification	Not available.	Not available.	Not available.	Not available.		Not available.

15. Regulatory information

U.S. Federal regulations

US INVENTORY (TSCA): In compliance.

This product is not regulated under Section 302 of SARA and 40 CFR Part 355.

SARA 313

Form R - Reporting requirements

This product does not contain any hazardous ingredients at or above regulated thresholds.

Supplier notification

This product does not contain any hazardous ingredients at or above regulated thresholds.

CERCLA Sections 102a/103 Hazardous Substances (40 CFR Part 302.4):: This material is not regulated under CERCLA Sections 103 and 107.

State regulations

No products were found.

California Prop 65: WARNING! This product contains trace amounts of the following chemicals which the State of California has found to cause cancer, birth defects or other reproductive harm.: Ethyl acrylate; Ethylene oxide; Dioxane

Inventories

AUSTRALIAN INVENTORY (AICS): In compliance.

CANADA INVENTORY (DSL): In compliance.

CHINA INVENTORY (IECS): Not determined.

EC INVENTORY (EINECS/ELINCS): In compliance.

JAPAN INVENTORY (ENCS): Not determined.

KOREA INVENTORY (ECL): In compliance.

PHILIPPINE INVENTORY (PICCS): In compliance.

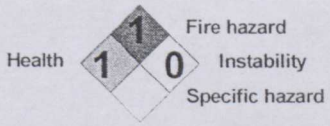
16. Other information

Label Requirements

CAUTION!

MAY CAUSE EYE IRRITATION.
MAY CAUSE SKIN IRRITATION.
MAY CAUSE RESPIRATORY TRACT IRRITATION.

HMIS® Rating :	Health	1	**National Fire Protection Association (U.S.A.)**
	Flammability	1	
	Physical Hazard	0	
	Personal protection	B	



Other special considerations

PETROLEUM OIL: STEL = 10 mg/M3. Using terminology of the International Agency for Research on Cancer (IARC), the petroleum distillates listed in Section II are classified by the supplier as severely processed. Not all those listed in Section II may be present. The supplier has stated that these distillates do not require a carcinogen label as defined by OSHA 29 CFR 1910.1200. No component known to be present in this product at >0.1% is presently listed as a carcinogen by IARC, NTP or OSHA.

History

Date of issue 03/03/2004.

Date of previous issue No Previous Validation.

Prepared by Product Stewardship

Notice to reader

NOTICE : This Material Safety Data Sheet is based upon data considered to be accurate at the time of its preparation. Despite our efforts, it may not be up to date or applicable to the circumstances of any particular case. We are not responsible for any damage or injury resulting from abnormal use, from any failure to follow appropriate practices or from hazards inherent in the nature of the product.

This Material Safety Data Sheet conforms to the requirements of ANSI Z400.1.

Material Safety Data Sheet

Prepared according to 29 CFR 1910.1200

1. Chemical Product and Company Identification

American Refining Group, Inc.
77 North Kendall Avenue
Bradford, PA 16701 USA
Tel: (814) 368.1200
www.amref.com

Product Name	Brad Penn® R&O ISO VG 22 Turbine/Hydraulic Oil
Product Code	BP7362
CAS Number	Not applicable for mixtures
Synonyms	Turbine/Hydraulic Oil
Generic Chemical Name	Petroleum hydrocarbon
Product Type	Mixture
Transportation Emergency Phone No.	Chemtrec: 1-800-424-9300 (24 HRS)
ARG Emergency Phone No.	814-368-1297 (24 HRS)
MSDS E-Mail	msds@amref.com

2. Hazards Identification

Appearance	Liquid
Odor	Petroleum Oil
Signal Word	CAUTION! May cause skin irritation Prolonged skin contact may cause irritation May cause eye irritation May cause respiratory tract irritation
OSHA Regulatory Status	This material is not considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200)
Precautions	
Inhalation	Avoid breathing dust/fume/gas/mist/vapors/spray. Keep container tightly closed. Use only with adequate ventilation.
Eyes	Avoid contact with eyes. Wash thoroughly after handling.
Skin	Avoid contact with skin and clothing. Wash thoroughly after handling.
Medical Conditions Aggravated by Exposure	Pre-existing disorders involving any target organs mentioned in this MSDS as being at risk may be aggravated by over-exposure to this product
Chronic Effects	See Section 11 for complete health hazard information
Environmental Effects	See Section 12 for complete ecological information

3. Composition / Information on Ingredients

This material is not considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200)

Component Regulatory Information	This product may be regulated, have exposure limits or other information identified as the following: Mineral Oil (See Section 8)

4. First Aid Measures

Eyes	Check for and remove any contact lenses. Immediately flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower eyelids. Get medical attention immediately.
Skin	In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. Clean shoes thoroughly before reuse. Get medical attention immediately.
Inhalation	Move exposed person to fresh air. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention immediately.
Ingestion	DO NOT INDUCE VOMITING. If conscious, rinse out mouth with water. Get medical attention immediately.
Note to Physicians	No specific treatment. Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.

5. Fire Fighting Measures

Flammable Properties
Not available
Extinguishing Media
Use dry chemical, CO_2, water spray (FOG) or foam
Specific Hazards Arising from Chemical
Elevated temperatures can lead to the formation of irritating fumes and vapors. Decomposition products may include the following materials: Carbon dioxide and Carbon monoxide.
Protective Equipment and Precautions for Firefighters
Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

6. Accidental Release Measures

Personal Precautions
No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. Shut off all ignition sources. No flares, smoking or flames in hazard area. Avoid breathing vapor or mist. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.
Environmental Precautions
Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution.

6. Accidental Release Measures

Methods for Containment

Stop leak if without risk.

Methods for Cleanup

Move containers from spill area. Approach release from upwind. Absorb with an inert dry material and place in an appropriate waste disposal container. Dispose of via a licensed waste disposal contractor.

7. Handling and Storage

Handling Procedures

Eating, drinking, and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. Do not get in eyes or on skin or clothing. Do not ingest. Avoid breathing vapor or mist. Use only with adequate ventilation. Use non-sparking tools.

Shipping and Storing Procedures

Store in accordance with local regulations. Store in a segregated and approved area. Keep in the original container protected from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials. Do not store in unlabeled containers. Store and use away from heat, sparks, open flame or any other ignition source. Take precautionary measures against electrostatic discharges. To avoid fire or explosion, dissipate static electricity during transfer by grounding and bonding containers and equipment before transferring material. Empty containers that retain product residue may be hazardous. Do not reuse container.

8. Exposure Controls / Personal Protection

Component Exposure Limits

Oil Mist (mineral)

ACGIH TLV:	TWA:	N/A ppm	TWA:	5 mg/m^3	STEL:	N/A ppm	STEL:	10 mg/m^3
OSHA PEL:	TWA:	N/A ppm	TWA	5 mg/m^3	STEL:	N/A ppm	STEL:	N/A mg/m^3
NIOSH REL:	TWA:	N/A ppm	TWA	5 mg/m^3	STEL:	N/A ppm	STEL:	10 mg/m^3

N/A signifies not available

Engineering Controls

Material should be handled in enclosed vessels and equipment. Use only in adequate ventilation. Use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits.

Eye/Face Protection

Chemical goggles or face shield.

Skin Protection

Chemical resistant, impervious gloves complying with an approved standard should be worn at all times. Coveralls, apron, and boots as necessary to minimize contact.

Respiratory Protection

Use a properly fitted, air-purifying or air-fed respirator complying with an approved standard if a risk assessment indicated this is necessary. Respirator selection must be based on known or anticipated exposure levels.

General Hygiene

Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing.

9. Physical and Chemical Properties

Appearance	Amber	**Vapor Pressure** (mm Hg at 20℃)	0
Odor	Petroleum oil	**Water Soluble**	No
Physical State	Liquid	**Specific Gravity** (g/cc)	.87
Flash Point (℉)	385	**Density** (lbs/gal)	7.15
Boiling Point (℉)	>625	**pH**	Not available

10. Chemical Stability & Reactivity Information

Stability Stable under normal conditions
Polymerization No polymerization
Incompatibility Strong acids and oxidizing materials
Conditions to Avoid High temperatures
Hazardous Decomposition Products Smoke, carbon monoxide, carbon dioxide, aldehydes and other products of incomplete combustion.

11. Toxicological Information

Acute Exposure

Respiratory Irritation If material is misted or if vapors are generated from heating, exposure may cause irritation of mucous membranes and the upper respiratory tract. Based on data from components or similar materials.

Eye Irritation May cause eye irritation. Vapors formed from heating may cause eye irritation.

Skin Irritation May cause skin irritation. Prolonged or repeated direct exposure to the skin may result in symptoms of irritation and redness, dermatitis or oil acne.

Sensitization Not expected to cause skin or respiratory sensitization.

Component Analysis – LD50 / LC50

Acute Toxicity Estimate (ATE) Values for Product:

Inhalation LC50 Rat	>100	mg/L 1 HR
Oral LD50 Rat	>5000	mg/kg
Dermal LD50 Rabbit	>2000	mg/kg

Chronic Exposure

Target Organ Effects No data available to indicate product or components present at greater than 1% are chronic health hazards.

Carcinogenicity This product contains mineral oils which are considered to be severely refined and not considered to be carcinogenic under IARC. All of the oils in this product have been demonstrated to contain less than 3% extractables by the IP 346 test.

Mutagenicity No data available to indicate product or any components present at greater than .1% are mutagenic or genotoxic.

Reproductive Toxicity No data available to indicate product or any components present at greater than .1% are a reproductive toxin.

Teratogenicity No data available to indicate product or any components contained at greater than .1% may cause birth defects.

12. Ecological Information

Component Analysis- Ecotoxicity – Aquatic Life

Duration/Test/Species	Concentration/Conditions
96 Hr LC50 Pimephales promelas	N/A mg/L

Degradability Not determined
Bioaccumulation Not determined
Soil Mobility Not determined

13. Disposal Considerations

Disposal Instructions
The generation of waste should be avoided or minimized wherever possible. Treatment, storage, transportation and disposal must be in accordance with applicable Federal, State/Provincial, and Local regulations.

14. Transportation Information

Emergency Response Guide No. 128 *North American Emergency Response Guide Book*

	UN Number	Shipping Name (technical name)	Hazard Class	Packing Group
U.S. DOT Bulk		Not Regulated		
U.S. DOT Non-Bulk		Not Regulated		

15. Regulatory Information

SARA Extremely Hazardous Substances (Sections 302 & 304) This product does not contain greater than 1% of any "extremely hazardous substances" listed pursuant to Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA) Section 302 or Section 304 as identified in 40 CFR Part 355, Appendix A and B.

SARA Section 313 This product does not contain greater than 1.0% of the substances subject to the reporting requirements of Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372.

SARA Section 311 & 312 Classifications

Acute Hazard	No
Chronic Hazard	No
Fire Hazard	No

15. Regulatory Information

Reactivity Hazard No

CERCLA This product does not contain any "hazardous substances" listed under the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) in 40 CFR Part 302, Table 302.4.

Clean Water Act / Oil Pollution Act This product contains petroleum distillates and may be subject to regulation by Section 311 of the Clean Water Act and the Oil Pollution Act. Releases of the product into or leading to surface waters must be reported to the National Response Center at 1-800-424-8802.

Global Chemical Inventories

Inventory	Component
	All components
US TSCA	Present
EU	Present
Japan	Not available
Australia	Present
New Zealand	Present
Canada	Present
Switzerland	Not available
Korea	Present
Philippines	Present
China	Present
Taiwan	Not available

16. Other Information

US NFPA Ratings

Health	Fire	Instability
0	1	0

HMIS Ratings

Health	Fire	Physical Hazards
0	1	0

Precautionary Labels

Signal Word Caution!
May cause skin irritation
Prolonged skin contact may cause irritation
May cause eye irritation
May cause respiratory tract irritation

Preparation/Revision Date 3/23/2012

Revision Reason MSDS out of date

Prepared By: Jenna Prechtl, Product Compliance Coordinator

The information provided on this MSDS is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guide for safe handling, use, processing, storage, transportation,

16. Other Information

disposal and release and is not to be considered as a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other material or in any process, unless specified in the text.

End of MSDS

1. Product and company identification

Product name	Hysol X
MSDS #	450877
Historic MSDS #:	01006-AE
Code	450877-US03
Product use	Lubricant
Manufacturer	Castrol Industrial North America, Inc. 150 W. Warrenville Road Naperville, IL 60563
Supplier	Castrol Industrial North America, Inc. 150 W. Warrenville Road Naperville, IL 60563 Product Information: 1-800-621-2661
EMERGENCY SPILL INFORMATION:	1 (800) 424-9300 CHEMTREC (USA)

2. Hazards identification

Physical state	Liquid.
Color	Yellow.
Emergency overview	WARNING! CAUSES EYE AND SKIN IRRITATION. MAY CAUSE ALLERGIC SKIN REACTION. MAY CAUSE RESPIRATORY TRACT IRRITATION. HARMFUL IF SWALLOWED. Prolonged or repeated contact can defat the skin and lead to irritation and/or dermatitis. Do not breathe vapor or mist. Do not ingest. Do not get on skin or clothing. Avoid contact with eyes. Use only with adequate ventilation. Keep container tightly closed and sealed until ready for use. Wash thoroughly after handling. Harmful if swallowed.
Routes of entry	Dermal contact. Eye contact. Inhalation. Ingestion.
Potential health effects	
Eyes	Causes eye irritation.
Skin	Causes skin irritation. May cause allergic skin reaction. Prolonged or repeated contact can defat the skin and lead to irritation and/or dermatitis.
Inhalation	May cause respiratory tract irritation.
Ingestion	Harmful if swallowed. Ingestion may cause gastrointestinal irritation and diarrhea.

See toxicological information (section 11)

3. Composition/information on ingredients

Ingredient name	CAS #	%
Base oil - highly refined	64742-52-5 &/or 64742-53-6	40 - 45
Alkanolamine PEG alkyl ether phosphate salt	Not available.	5 - 10
Boric acid	10043-35-3	1 - 5
2,2',2"-(hexahydro-1,3,5-triazine-1,3,5-triyl)triethanol	4719-04-4	1 - 5
Sodium sulfonate	68608-26-4	1 - 5
Base oil - highly refined Mixture.	64741-88-4 &/or 64742-54-7 &/or 64741-96-4 &/or 64742-52-5	1 - 5

4. First aid measures

Eye contact In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention.

Skin contact Immediately wash exposed skin with soap and water. Remove contaminated clothing and shoes. Wash clothing before reuse. Clean shoes thoroughly before reuse. In the event of any complaints or symptoms, avoid further exposure. Get medical attention.

Inhalation If inhaled, remove to fresh air. Get medical attention if symptoms occur.

Ingestion Do not induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. If potentially dangerous quantities of this material have been swallowed, call a physician immediately. Get medical attention.

5. Fire-fighting measures

Flash point Water content interferes with flash point determination.

Fire/explosion hazards In a fire or if heated, a pressure increase will occur and the container may burst.

Unusual fire/explosion hazards Non-explosive in the presence of the following materials or conditions: open flames, sparks and static discharge, heat, shocks and mechanical impacts and oxidizing materials.

Extinguishing media

Suitable Use an extinguishing agent suitable for the surrounding fire.

Not suitable Do not use water jet.

Fire-fighting procedures Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training.

Hazardous combustion products Combustion products may include the following:
metal oxide/oxides
carbon oxides (CO, CO_2) (carbon monoxide, carbon dioxide)
sulfur oxides (SO_2, SO_3 etc.)
nitrogen oxides (NO, NO_2 etc.)

Protective clothing (fire) Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

6. Accidental release measures

Personal precautions No action shall be taken involving any personal risk or without suitable training. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. In accordance with good industrial hygiene and safety work practices, airborne exposures should be controlled to the lowest extent practicable. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment (see section 8).

Environmental precautions Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods for cleaning up

Large spill

Stop leak if without risk. Move containers from spill area. Approach release from upwind. Prevent entry into sewers, water courses, basements or confined areas. Wash spillages into an effluent treatment plant or proceed as follows. Contain and collect spillage with non-combustible, absorbent material e.g. sand, earth, vermiculite or diatomaceous earth and place in container for disposal according to local regulations (see section 13). Dispose of via a licensed waste disposal contractor. Contaminated absorbent material may pose the same hazard as the spilled product. Note: see section 1 for emergency contact information and section 13 for waste disposal.

Small spill

Stop leak if without risk. Move containers from spill area. Dilute with water and mop up if water-soluble or absorb with an inert dry material and place in an appropriate waste disposal container. Dispose of via a licensed waste disposal contractor.

7. Handling and storage

Handling

Put on appropriate personal protective equipment (see section 8). Workers should wash hands and face before eating, drinking and smoking. Persons with a history of skin sensitization problems should not be employed in any process in which this product is used. Do not get in eyes or on skin or clothing. Do not breathe vapor or mist. Do not ingest. Use only with adequate ventilation. Wear appropriate respirator when ventilation is inadequate.

Storage

Store in accordance with local regulations. Store away from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see section 10). Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabeled containers. Use appropriate containment to avoid environmental contamination.

Other information

DO NOT ADD NITRITES TO THIS FLUID.

8. Exposure controls/personal protection

Occupational exposure limits

Ingredient name	Occupational exposure limits
Base oil - highly refined	**ACGIH (United States).** STEL: 10 mg/m³ 15 minute(s). Form: Oil mist, mineral TWA: 5 mg/m³ 8 hour(s). Form: Oil mist, mineral **OSHA (United States).** TWA: 5 mg/m³ 8 hour(s). Form: Oil mist, mineral
Boric acid	**ACGIH TLV (United States, 1/2007).** STEL: 6 mg/m³ 15 minute(s). TWA: 2 mg/m³ 8 hour(s).
Base oil - highly refined Mixture.	**OSHA (United States).** TWA: 5 mg/m³ 8 hour(s). Form: Mist **ACGIH (United States).** TWA: 5 mg/m³ 8 hour(s). Form: Mist STEL: 10 mg/m³ 15 minute(s). Form: Mist

While specific OELs for certain components may be shown in this section, other components may be present in any mist, vapor or dust produced. Therefore, the specific OELs may not be applicable to the product as a whole and are provided for guidance only.

Some states may enforce more stringent exposure limits.

Control Measures

Use only with adequate ventilation. If user operations generate dust, fumes, gas, vapor or mist, use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits.

Hygiene measures

Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing.

Personal protection

Eyes

Avoid contact with eyes. Safety glasses with side shields or chemical goggles.

Skin and body

Do not get on skin or clothing. Wear suitable protective clothing.

Respiratory	Use adequate ventilation. In accordance with good industrial hygiene and safety work practices, airborne exposures should be controlled to the lowest extent practicable.
Hands	The correct choice of protective gloves depends upon the chemicals being handled, the conditions of work and use, and the condition of the gloves (even the best chemically resistant glove will break down after repeated chemical exposures). Most gloves provide only a short time of protection before they must be discarded and replaced. Because specific work environments and material handling practices vary, safety procedures should be developed for each intended application. Gloves should therefore be chosen in consultation with the supplier/manufacturer and with a full assessment of the working conditions.

9. Physical and chemical properties

Physical state	Liquid.
Color	Yellow.
Flash point	Water content interferes with flash point determination.
Specific gravity	0.97 to 0.99
Volatility	10% (v/v)
Evaporation rate	<1 (Butyl acetate. = 1)
VOC	218.75 g/l
Solubility	Soluble in water.

10. Stability and reactivity

Stability and reactivity	The product is stable.
Conditions to avoid	Not available.
Incompatibility with various substances	Reactive or incompatible with the following materials: oxidizing materials.
Hazardous decomposition products	Under normal conditions of storage and use, hazardous decomposition products should not be produced.
Hazardous polymerization	Under normal conditions of storage and use, hazardous polymerization will not occur.

11. Toxicological information

Other information

Alkanolamine: This product contains an alkanolamine. In all metalworking fluids containing amines, there is a potential for forming nitrosamines which are animal carcinogens. Therefore, no nitrites or related nitrosating agents should be added to such compositions.

Reproduction/Developmental: Animal ingestion studies in several species, at high doses, indicate that boric acid and certain inorganic borates can cause reproductive and developmental effects. A human study of occupational exposure to borate dust showed no adverse effect on reproduction.

Target organs: No target organ has been identified in humans. High Dose animal ingestion studies indicate the testes are the target organ in male animals.

These industrial products are not intended for ingestion.

This product contains a preservative that may release trace amounts of formaldehyde during use.

This product contains a preservative that may release trace amounts of formaldehyde during use. Employers are required under 29 CFR 1910.1048, Formaldehyde, to determine if formaldehyde levels exceed 0.1 ppm in the workplace. Employers may be required to provide employee information and training regarding the hazards of formaldehyde, unless the employer can show, using objective data, that the employees are not exposed to formaldehyde at or above 0.1 ppm. This regulation also requires routine monitoring if exposure levels exceed OSHA's action level of 0.5 ppm. Employers should consult OSHA's Formaldehyde Standard for additional information. ACGIH STEL=0.3 ppm.

Potential chronic health effects

Carcinogenicity	No known significant effects or critical hazards.
Reproductive effects	See Other Information
Medical conditions aggravated by over-exposure	Pre-existing skin disorders may be aggravated by over-exposure to this product.

12. Ecological information

No testing has been performed by the manufacturer.

13. Disposal considerations

Waste information

The generation of waste should be avoided or minimized wherever possible. Empty containers or liners may retain some product residues. This material and its container must be disposed of in a safe way. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.

NOTE: The generator of waste has the responsibility for proper waste identification (based on characteristic(s) or listing), transportation and disposal

14. Transport information

Not classified as hazardous for transport (DOT, TDG, IMO/IMDG, IATA/ICAO)

15. Regulatory information

U.S. Federal regulations

United States inventory (TSCA 8b): All components are listed or exempted.

SARA 302/304/311/312 extremely hazardous substances: No products were found.
SARA 302/304 emergency planning and notification: No products were found.
SARA 302/304/311/312 hazardous chemicals: Boric acid
SARA 311/312 MSDS distribution - chemical inventory - hazard identification: Hysol X: Immediate (acute) health hazard, Delayed (chronic) health hazard

SARA 313

Form R - Reporting requirements	This product does not contain any hazardous ingredients at or above regulated thresholds.
Supplier notification	This product does not contain any hazardous ingredients at or above regulated thresholds.
CERCLA Sections 102a/103 Hazardous Substances (40 CFR Part 302.4):	CERCLA: Hazardous substances.: sodium dodecylbenzene sulfonate: 1000 lbs. (454 kg); Formaldehyde.: 100 lbs. (45.4 kg); 1,4-dioxane: 100 lbs. (45.4 kg); Ethylene oxide: 10 lbs. (4.54 kg);

State regulations

Massachusetts Substances	**Massachusetts Substances**: None of the components are listed.
New Jersey Hazardous Substances	**New Jersey Hazardous Substances**: None of the components are listed.
Pennsylvania RTK Hazardous Substances	**Pennsylvania RTK Hazardous Substances**: None of the components are listed.

California Prop. 65	**WARNING:** This product contains a chemical known to the State of California to cause cancer. 1,4-dioxane; Formaldehyde. **WARNING:** This product contains a chemical known to the State of California to cause cancer and birth defects or other reproductive harm. Ethylene oxide
Inventories	**Canada inventory:** All components are listed or exempted. **Europe inventory:** All components are listed or exempted. **Australia inventory (AICS):** All components are listed or exempted. **China inventory (IECSC):** All components are listed or exempted. **Japan inventory (ENCS):** Not determined. **Korea inventory (KECI):** All components are listed or exempted. **Philippines inventory (PICCS):** All components are listed or exempted.

16. Other information

Label requirements

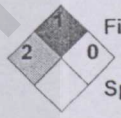
WARNING!

CAUSES EYE AND SKIN IRRITATION.
MAY CAUSE ALLERGIC SKIN REACTION.
MAY CAUSE RESPIRATORY TRACT IRRITATION.
HARMFUL IF SWALLOWED.

HMIS® Rating :

Health	* 1
Flammability	1
Physical Hazard	0
Personal protection	B

National Fire Protection Association (U.S.A.)



Fire hazard
Instability
Specific hazard

History

Date of issue	02/06/2008.
Date of previous issue	10/02/2007.
Prepared by	Product Stewardship

Notice to reader

All reasonably practicable steps have been taken to ensure this data sheet and the health, safety and environmental information contained in it is accurate as of the date specified below. No warranty or representation, express or implied is made as to the accuracy or completeness of the data and information in this data sheet.

The data and advice given apply when the product is sold for the stated application or applications. You should not use the product other than for the stated application or applications without seeking advice from us.

It is the user's obligation to evaluate and use this product safely and to comply with all applicable laws and regulations. The BP Group shall not be responsible for any damage or injury resulting from use, other than the stated product use of the material, from any failure to adhere to recommendations, or from any hazards inherent in the nature of the material. Purchasers of the product for supply to a third party for use at work, have a duty to take all necessary steps to ensure that any person handling or using the product is provided with the information in this sheet. Employers have a duty to tell employees and others who may be affected of any hazards described in this sheet and of any precautions that should be taken.

The Leading Lubricant Specialist

SAFETY DATA SHEET

1: IDENTIFICATION OF THE SUBSTANCE / PREPARATION AND OF THE COMPANY / UNDERTAKING

Product Name: **Ilocut 603**

Application: Metalworking fluid - Neat

Company: **Castrol (U.K.) Limited**

Address: Burmah Castrol House, Pipers Way, Swindon, Wiltshire, SN3 1RE

Telephone (24 hours): 01793 512712 Fax: 01793 432872

2: COMPOSITION/INFORMATION ON INGREDIENTS

Composition: Highly refined mineral oil and additives

All constituents of this product are listed in EINECS (European Inventory of Existing Commercial Chemical Substances) or ELINCS (European List of New Chemical Substances) or are exempt.

Refer to Section 8 for Occupational Exposure Limits.

3: HAZARDS IDENTIFICATION

This product is NOT classified as hazardous

4: FIRST AID MEASURES

Eyes: Irrigate immediately with copious quantities of water for several minutes

Skin: Wash thoroughly with soap and water or suitable skin cleanser as soon as possible

Inhalation: Remove from exposure

Ingestion: Obtain medical attention. Do NOT induce vomiting.

5: FIRE FIGHTING MEASURES

Suitable Extinguishing Media: Carbon dioxide, powder,foam or water fog - Do not use water jets

Special Exposure Hazards: None

Special Protective Equipment: None

6: ACCIDENTAL RELEASE MEASURES

Personal Precautions: Spilt product presents a significant slip hazard

Environmental Precautions: Prevent entry into drains, sewers and water courses

Decontamination Procedures: Soak up with inert absorbent or contain and remove by best available means

7: HANDLING AND STORAGE

Handling: To avoid the possibility of skin disorders, repeated or prolonged contact with products of this type must be avoided. It is essential to maintain a high standard of personal hygiene
Avoid breathing spray mist.

Storage: No special precautions

8: EXPOSURE CONTROLS/PERSONAL PROTECTION

Occupational Exposure Limits:-

Engineering Control Measures: Local exhaust ventilation is recommended. Mechanical methods to minimise exposure must take precedence over personal protective measures.

Personal Protective Equipment: Safety glasses. Plastic apron. Wear impervious gloves (eg of PVC), in case of repeated or prolonged contact. Change contaminated clothing and clean before re-use.

9: PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Liquid
Colour:	Amber
Odour:	Mild
Kinematic Viscosity @ 40°C (cSt):	33
Flash Point (opened, °C)	Above 200
Autoignition (°C):	Above 250
Explosive Properties (%):	Not determined
Relative Density (at 20°C):	Below 1.0
Water Solubility:	Insoluble
Fat Solubility:	Not determined

10: STABILITY AND REACTIVITY

Stability: Stable. Hazardous polymerisation will not occur.

Conditions to Avoid: Temperatures (°C) above 100

Materials to Avoid: Strong oxidising agents

Hazardous Decomposition Products: None

11: TOXICOLOGICAL INFORMATION

The following toxicological assessment is based on a knowledge of the toxicity of the product's components
Expected oral LD_{50}, rat > 2g/kg. Expected dermal LD_{50}, rabbit > 2g/kg.

Health Effects

On Eyes: May cause transient irritation

On Skin:	Unlikely to cause harm on brief or occasional contact
By Inhalation:	Mist and vapours may cause irritation to nose and respiratory tract
By Ingestion:	May cause nausea, vomiting and diarrhoea
Chronic:	Repeated and prolonged skin contact may lead to skin disorders
Other:	None known

12: ECOLOGICAL INFORMATION

Environmental Assessment:	When used and disposed of as intended, no adverse environmental effects are foreseen
Mobility:	Involatile. Mobile liquid. Insoluble in water.
Persistence and Degradability:	Inherently biodegradable
Bioaccumulative Potential:	Bioaccumulative based on logP values of constituents
Ecotoxicity:	Not determined

13: DISPOSAL CONSIDERATIONS

Disposal must be in accordance with local and national legislation.

Unused Product:	May be sent for reclamation Dispose of through an authorised waste contractor to a licensed site
Used/Contaminated Product:	As for Unused Product For further information see Section 16
Packaging:	Must be disposed of through an authorised waste contractor May be steam cleaned and recycled

14: TRANSPORT INFORMATION

This product is NOT classified as dangerous for transport

15: REGULATORY INFORMATION

Hazard Label Data:-

This product is NOT classified as dangerous for supply in the UK

EC Directives:	Waste Oil Directive, 87/101/EEC Framework Waste Directive, 91/156/EEC
Statutory Instruments:	Health & Safety at Work, etc. Act 1974 Consumer Protection Act 1987 Environmental Protection Act 1990
Codes of Practice:	Waste Management. The Duty of Care
Guidance Notes:	Occupational skin diseases: health and safety precautions (EH 26) Occupational exposure limits (EH 40) Carcinogenicity of mineral oils (EH 58) Metalworking fluids - health precautions (EH 62) Skin cancer caused by oil [MS(B)5] Save your skin! - Occupational Contact Dermatitis [MS(B)6] Dermatitis - cautionary notice [SHW 367] Effects of mineral oil on the skin [SHW 397]

The above publications are available from HMSO or HSE

16: OTHER INFORMATION

Castrol publication: Talking About Health and Safety - Lubricants and Allied Products
Castrol Advice Sheet: The Disposal of Used Metalworking Fluids
Castrol publication: Talking about Cutting Fluids

The data and advice given apply when the product is sold for the stated application or applications. The product is not sold as suitable for any other application. Use of the product for applications other than as stated in this sheet may give rise to risks not mentioned in this sheet. You should not use the product other than for the stated application or applications without seeking advice from us.

If you have purchased the product for supply to a third party for use at work, it is your duty to take all necessary steps to secure that any person handling or using the product is provided with the information in this sheet.

If you are an employer, it is your duty to tell your employees and others who may be affected of any hazards described in this sheet and of any precautions which should be taken.

Further copies of this Safety Data Sheet may be obtained from Castrol (U.K.) Limited.

Henkel

Henkel Central Eastern Europe GmbH
Division Technologies
Erdbergstr. 29
1030 Wien
Austria
Phone: +43-1-71104-0
Fax: +43-1-71104-2534

Henkel & Cie. AG
Industrial Division
Hardstraße 55
4133 Pratteln
Switzerland
Phone: +41-61-8250-401
Fax: +41-61-8250-333

Henkel KGaA
Henkelstr. 67
40191 Düsseldorf
Germany
Surface Treatment
Phone: +49-211-797-3000
Fax: +49-211-798-2376

Email: surface.technologies@henkel.com
Internet: www.henkel-technologies.com

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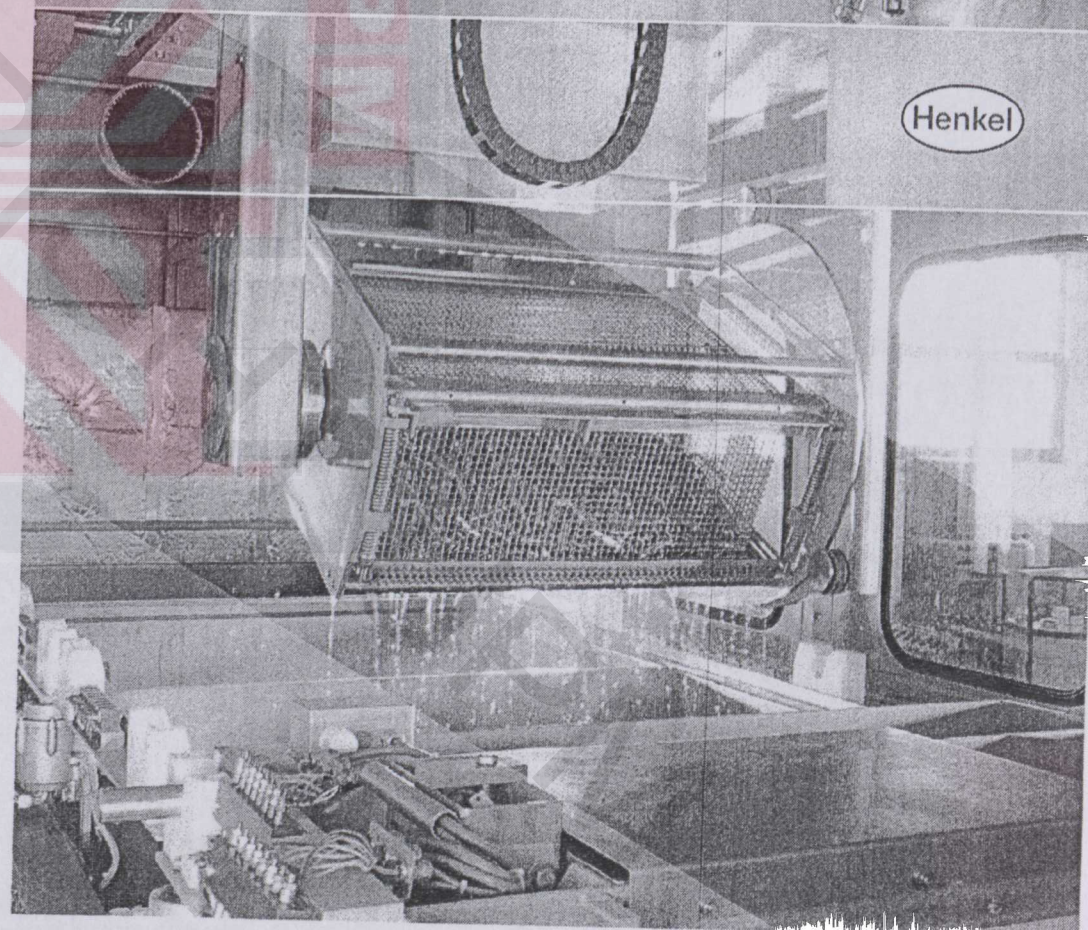
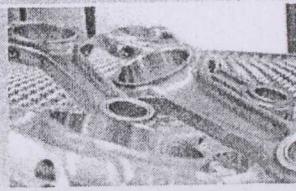
Product Overview
Cleaners

Henkel



Range – for Total Process



Product	Short Description	Consistency	Application	Substrate to be Cleaned / Material Resistance								Working Temperature °C		pH-value (1 % in DI-water
				Steel/ Iron	Cast Iron	Zinc	Al-Knead Alloys	Al-Cast Alloys	Magne-sium	Copper	Brass	min	max	
Alkaline Cleaners														
P3-almeco 18	Basic ingredients: carbonates, borates and phosphates. For aluminium parts without etching.	P	dip/us	▩	▩	■	▩	▩	▩	▩	▩	60	90	9.2
P3-almeco 36	Basic ingredients: carbonates, borates and phosphates. High performance cleaning of aluminium parts.	P	spray/dip	▩	▩	■	▩	▩	▩	▩	▩	50	90	9.4
P3-galvaclean 45	Basic ingredients: carbonates and phosphates. For various metals with low soil level. Slight etching of aluminium and its alloys.	P	dip	▩	▩	▩	▩	▩	▩	▩	▩	50	80	12.0
P3-galvaclean 65	Basic ingredients: carbonates and silicates. For steel and zincated steel prior to phosphating.	P	ed	▩	▩	▩	▩	■	▩	▩	▩	20	60	13.0
Ridoline 1427	Basic ingredients: phosphates. For steel prior to phosphating, silicate-free.	P	dip	▩	▩	■	▩	■	▩	▩	▩	50	80	12.8
Ridoline 1562	Basic ingredients: borates, phosphates and silicates. For all materials prior to phosphating, surfactant-free.	L	spray/dip	▩	▩	▩	▩	▩	▩	▩	▩	50	80	12.2
Ridoline 1563	Basic ingredients: carbonates and phosphates. For steel, zinc and aluminium alloys prior to phosphating.	L	spray/dip	▩	▩	▩	▩	▩	▩	▩	▩	50	80	11.6
P3-upon 4100	Basic ingredients: phosphates. High performance cleaner for steel and cast iron with heavy soils incl. pigments.	P	spray	▩	▩	■	▩	■	▩	■	■	45	60	11.5
P3-emalan 5669	Basic ingredients: silicates, phosphates and alkalines. Specially suitable for multi-metal, two-component system best cleaning results with surfactant additive.	L	spray/dip	▩	▩	▩	▩	▩	▩	▩	▩	–	–	12.2
P3-upon	Basic ingredients: phosphates. High performance cleaner for steel, cast iron with heavy soils incl. pigments and after cutting, stamping pressing or cold forming.	P	spray	▩	▩	■	▩	■	▩	■	■	45	80	12.0
P3-upon 5805	Basic ingredients: phosphates and surfactants. Cleaner for the removal of heavy soils and greasy contamination as well as pigmented, fatty acid containing drawing compounds from steel in immersion process.	L	dip	▩	▩	■	▩	■	▩	■	■	40	80	11.6
P3-upon 6444	Basic ingredients: alkalines and phosphonates. Two-component cleaner for ferrous metals for cleaning after cutting, stamping, pressing or cold forming.	L	spray/dip	▩	▩	■	▩	■	▩	■	■	–	–	12.5
P3-saxin	Basic ingredients: silicates, phosphates and carbonates. Specially suitable for multi-metal in spray process after cutting, stamping and pressing in manufactoring industries.	P	spray	▩	▩	▩	▩	▩	▩	▩	▩	50	80	12.0
P3-WO	Basic ingredients: silicates, alkalines, carbonates and surfactants. Degreasing of heavily soiled and greasy steel and copper surfaces and it alloys in immersion processes.	P	dip	▩	▩	■	▩	■	▩	▩	▩	60	80	12.5
Ridoline 2102 IT	Basic ingredients: phosphates. Low alkalinity cleaner suitable for all metals prior to phosphating, BonderiteNT, small appliance cleaning.	L	spray	▩	▩	▩	▩	▩	▩	▩	▩	45	65	–

P3-Cleaners: All cleaners fulfil the EU Detergency Regulation (EC) No. 648 / 2004 dated 31st March 2004 valid since 8th October 2005

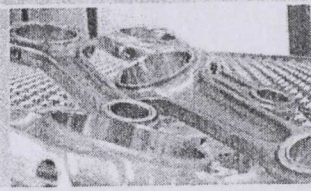
Consistency P: Powder L: Liquid

Substrate ▩ : Material can be cleaned ■ : Material must not be cleaned

Application ed: electrolytic degreasing us: ultrasonic

▩ : Material could be cleaned, must be tested prior to use

...rm Range – for Total Process ...



Product	Short Description	Consistency	Application	Substrate to be Cleaned / Material Resistance								Working Temperature °C		pH-value (1 % in DI-water)
				Steel/ iron	Cast iron	Zinc	Al-Knead Alloys	Al-Cast Alloys	Magne-sium	Copper	Brass	min	max	
Alkaline Cleaners														
Ridoline 2153 IT	Basic ingredients: phosphates. Free of silicate and non ionic surfactant. Medium alkaline cleaner prior to phosphating, BonderiteNT, small appliance cleaning and before enammeling.	L	spray	■	■	■	■	■	■	■	■	40	70	–
Ridoline 2260 IT	Basic ingredients: alkalines and complexing agents. Multipurpose surfactant-free base for Al etching, dephosphating, paint stripping, cleaning and electrocleaning.	L	spray/dip	■	■	■	■	■	■	■	■	45	60	13.0
Ridoline 2500 IT	Basic ingredients: silicates, phopsphates and surfactants. Multimetal cleaner for various applications.	P	dip	■	■	■	■	■	■	■	■	50	70	12.0
Lixton 3402 S	Basic ingredients: phosphates. Demulsifying mild alkaline cleaner with high performance for steel and cast iron with heavy soils incl. pigments.	L	spray/dip/us	■	■	■	■	■	■	■	■	40	80	9.5
Ridoline 409 A	Alkaline cleaner, silicate-free, with low etch for aluminium.	L	spray	■	■	■	■	■	■	■	■	–	–	–
Novadip 4113	Basic ingredients: silicates, phosphates, carbonates and surfactants. Good cleaning of all metals especially for aluminium alloys in immersion processes.	P	dip	■	■	■	■	■	■	■	■	–	–	11.6
Ridoline 7163 CF/5	Basic ingredients: phosphates, alkaline hydroxides, and complexing agents. Free of silicate and surfactant. For steel and partly zinc plated steel, surfactant-free.	L	spray/dip	■	■	■	■	■	■	■	■	55	70	13.0
P3-galvaclean C 32	Basic ingredients: carbonates, phosphates, surfactants, alkaline hydroxides, silicates and complexing agents. Cleaner for dip applications on steel substrates.	P	dip	■	■	■	■	■	■	■	■	60	95	12.5
P3-industril FA	Basic ingredients: phosphonates, salts, organic components and surfactants. Suitable for nearly all materials (metals and plastics) and processes. Degrasing of machinery parts in manual, dip and spray applications.	L	spray/dip	■	■	■	■	■	■	■	■	–	–	11.1
Ridoline G 1550 L	Basic ingredients: phosphates, alkali hydroxides, silicates and complexing agents. Strongly recommended for bicomponent for all metals.	L	spray/dip	■	■	■	■	■	■	■	■	40	70	13.0
Novaclean L 95	Basic ingredients: alkali hydroxides and complexing agents. High alkaline cleaner with surfactant for heavy duty immersion cleaning of steel parts, incl. electrolytic cleaning. For spray applications prior to phosphating. Suitable for hard water.	L	spray/dip/us	■	■	■	■	■	■	■	■	40	80	13.0
Lixton SFR 3611	Basic ingredients: gluconates. Mould cleaner for steel to remove release agent and rubber without attack on the base material.	L	dip/us	■	■	■	■	■	■	■	■	40	80	13.5
Novaclean STL	Basic ingredients: phosphates, alkali hydroxides and complexing agents. Recommended for electrolytical degreasing, descaler / deruster, paint stripper, aluminium etching.	L	dip/spray	■	■	■	■	■	■	■	■	20	80	13.0

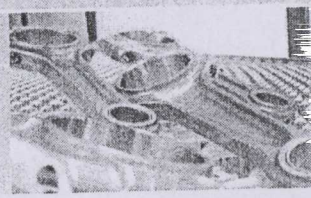
P3-Cleaners: All cleaners fulfil the EU Detergency Regulation (EC) No. 648 / 2004 dated 31st March 2004 valid since 8th October 2005

Consistency P: Powder L: Liquid

Application ed: electrolytic degreasing us: ultrasonic

Substrate ■ : Material can be cleaned ■ : Material must not be cleaned ■ : Material could be cleaned, must be tested prior to use

...ner Range – for Total Process ...



Product	Short Description	Consistency	Application	Substrate to be Cleaned / Material Resistance								Working Temperature °C		pH-value (1 % in DI-water)
				Steel/ Iron	Cast Iron	Zinc	Al-Kneed Alloys	Al-Cast Alloys	Magne-sium	Copper	Brass	min	max	
Alkaline Cleaners with Temporary Corrosion Protection														
P3-galvaclean 20	Basic ingredients: alcanolamines and surfactants. All-purpose immersion (with or without ultrasonic) cleaner, leaves hydrophobic surface. For the final and intermediate cleaning, excellent for removing of polishing pastes.	L	dip/us	▩	▩	▩	▩	▩	▩	▩	▩	50	80	8.6
P3-upon 5800	Basic ingredients: phosphates and surfactants. Cleaner for the removal of heavy soils and greasy contamination as well as pigmented, fatty acid containing drawing compounds from steel in spray application.	L	spray	▩	▩	■	▩	■	▩	■	■	40	80	12.0
P3-upon 5801	Basic ingredients: phosphonates, salts, organic components, alkalines and surfactants. Removing of heavily soiled and greasy contaminations as well as pigmented, fatty acid containing drawing compounds from steel and plastic by spray application.	L	spray	▩	▩	■	▩	■	▩	■	■	50	80	12.3
Acid Cleaner														
Chemalyt 144	Basic ingredients: phosphoric acids. Immersion cleaning and degreasing of iron, steel, copper, brass and aluminium surfaces with no major metal attack.	L	dip	▩	▩	▩	▩	▩	■	▩	▩	70	85	1.6
Chemalyt 146	Basic ingredients: phosphoric acids. Spray cleaning and degreasing of iron, steel, copper, brass and aluminium surfaces with no major metal attack.	L	spray	▩	▩	▩	▩	▩	■	▩	▩	60	70	1.6
Chemacid 3400	Basic ingredients: phosphoric- / sulphuric acids. For iron, steel and aluminium. Suitable for heavy duty operations.	L	dip	▩	▩	▩	▩	▩	▩	▩	▩	50	90	1.6
Novaclean N	Basic ingredients: complexing agents and organic acids. Neutral derusting, particularly after deburring operations replacing conventional acidic multi-stage operations.	L	dip/spray	▩	▩	▩	▩	▩	▩	▩	▩	20	80	5.0
GABROPOL RD	Basic ingredients: surfactants and mineral acids. Strong deoxidizer. High performance pickling prior to heavy phosphating (Zn, Mn). Used instead of sandblasting.	L	dip	▩	▩	▩	▩	▩	▩	▩	▩	20	40	2.0

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Consistency P: Powder L: Liquid

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Application ed: electrolytic degreasing us: ultrasonic

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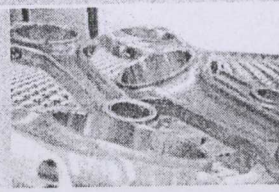
... Range – for Total Process ...



Product	Short Description	Consistency	Application	Substrate to be Cleaned / Material Resistance								Working Temperature °C		pH-value (1 % in DI-wa
				Steel/ Iron	Cast Iron	Zinc	Al-Knead Alloys	Al-Cast Alloys	Magne-sium	Copper	Brass	min	max	
Corrosion Protection														
P3-gero cor 3	Corrosion Protection oil (6–12 months).	L	spray/dip	■	■	■	■	■	■	■	■	15	30	–
P3-emulpon 6765	2 in 1 product, cutting fluid and corrosion protection emulsion (5–6 months). Water miscible cutting fluid for general machining.	L	spray/dip	■	■	■	■	■	■	■	■	50	80	–
P3-emulpon 6771	Corrosion protection emulsion (2–3 months), suitable only for soft water.	L	spray/dip	■	■	■	■	■	■	■	■	20	80	9.5
P3-emulpon 6776	Corrosion protection emulsion (3–4 months), suitable from 15°dH upward.	L	spray/dip	■	■	■	■	■	■	■	■	40	80	9.2
P3-prevox 7400	Aqueous corrosion protective (2–3 days). Ideal prior to painting. Passivation of steel and cast iron for subsequent storage in closed warehouses.	L	spray/dip	■	■	■	■	■	■	■	■	20	80	9.8
P3-prevox 6738 N	Amine-free aqueous corrosion protective (4–8 weeks), passivating of steel and cast iron for subsequent storage in closed warehouses.	L	spray/dip	■	■	■	■	■	■	■	■	20	80	8.4
P3-prevox 6740-6	Aqueous corrosion protective for short term indoor storage (2–3 weeks).	L	spray/dip	■	■	■	■	■	■	■	■	20	80	9.0
P3-emulpon 97-10	Corrosion protection emulsion suitable for soft and hard water. Replenished by drag in of Multan 97–10 cutting-fluid. Non foaming in cold water.	L	spray	■	■	■	■	■	■	■	■	20	80	9.1
Lixton SV 2	Basic ingredients: isoparaffinic hydrocarbons. Dewatering fluid, temporary corrosion protection, no VOC.	L	spray/dip	■	■	■	■	■	■	■	■	20	40	–
Lixton TS 941	Basic ingredients: isoparaffinic hydrocarbons, corrosion inhibitors. Dewatering fluid, temporary corrosion protection, film not visible, performance > 25 cycles condensed water test.	L	spray/dip	■	■	■	■	■	■	■	■	20	40	–

P3-Cleaners: All cleaners fulfil the EU Detergency Regulation (EC) No. 648 / 2004 dated 31st. March 2004 valid since 8th. October 2005

Consistency P: Powder L: Liquid

Application ed: electrolytic degreasing us: ultrasonic

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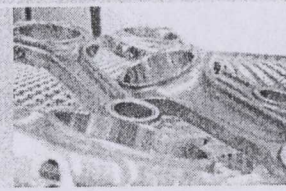

Product	Short Description	Consistency	Application	Substrate to be Cleaned / Material Resistance								Working Temperature °C		pH-value (1 % in DI-wat
				Steel/ iron	Cast iron	Zinc	Al-Kneed Alloys	Al-Cast Alloys	Magne-sium	Copper	Brass	min	max	
Neutral Cleaners with Organic Corrosion Inhibitors – Salt-free														
P3-neutracare 250	Basic ingredients: amines, carboxylic acids. All-purpose cleaner with high biostability. 100% permeability on UF.	L	spray/ high pressure	■	■	■	■	■	■	■	■	20	80	9.3
P3-neutracare 270	Basic ingredients: amines, carboxylic acids. All-purpose cleaner especially suitable for aluminium and magnesium alloys. 100% permeability on UF.	L	spray	■	■	■	■	■	■	■	■	30	80	10.7
P3-neutracare 300	Basic ingredients: amines, carboxylic acids. Standard cleaner with very good surface finish. 100% permeability on UF.	L	spray/ high pressure	■	■	■	■	■	■	■	■	20	80	8.9
P3-neutracare 310	Basic ingredients: amines, carboxylic acids. Cold sprayable cleaner with good cleaning performance and corrosion protection.	L	spray/ high pressure	■	■	■	■	■	■	■	■	20	80	8.9
P3-neutracare 400	Basic ingredients: amines, carboxylic acids. Cleaner with excellent corrosion protection. 100% permeability on UF.	L	spray/ high pressure	■	■	■	■	■	■	■	■	20	80	7.7
P3-neutracare 3300	Basic ingredients: amines, carboxylic acids. Self-demulsifying neutral cleaner. Excellent cleaning performance.	L	spray/ high pressure	■	■	■	■	■	■	■	■	30	80	9.1
P3-neutracare 3310	Basic ingredients: amines, carboxylic acids. Self-demulsifying neutral cleaner. Contains fungicide.	L	spray/ high pressure	■	■	■	■	■	■	■	■	30	80	9.7
P3-neutrapon 5065	Basic ingredients: amines, carboxylic acids. Standard neutral cleaner, biostable formulation.	L	spray	■	■	■	■	■	■	■	■	50	80	9.4
P3-neutrapon 5072	Basic ingredients: amines, carboxylic acids. Highly concentrated. Suitable for highly burdened systems.	L	spray	■	■	■	■	■	■	■	■	60	80	9.4
P3-neutrapon 5088	Best-in-Class salt-free neutral cleaner. Excellent cleaning performance, also suitable for non-ferrous metals, cleaning prior to hardening processes.	L	spray	■	■	■	■	■	■	■	■	55	80	8.6
Neutral Cleaners with Organic Corrosion Inhibitors – Salt-containing														
P3-neutracare 750	Basic ingredients: amines, carboxylic acids. Neutral cleaner for heavy duty cleaning operations. Improved biostability. 100% permeability on UF.	L	spray/ high pressure	■	■	■	■	■	■	■	■	20	80	9.4
P3-neutracare 3700	Basic ingredients: amines, carboxylic acids. Self-demulsifying neutral cleaner with high cleaning performance.	L	spray/ high pressure	■	■	■	■	■	■	■	■	30	80	9.5
P3-neutrapon 175	Basic ingredients: amines, carboxylic acids, phosphates. Neutral cleaner with excellent cleaning performance for light pigment soiling and lapping paste.	L	spray/dip	■	■	■	■	■	■	■	■	50	80	9.6
P3-neutrapon 5230	Basic ingredients: amines, carboxylic acids. Neutral cleaner with excellent cleaning performance for light pigment soiling and lapping pastes. Foam-free even when contaminated with coolant emulsion.	L	spray	■	■	■	■	■	■	■	■	20	80	9.6
P3-neutrasel 5225	Basic ingredients: amines, carboxylic acids, phosphates. Cold sprayable neutral cleaner.	L	spray/ high pressure	■	■	■	■	■	■	■	■	20	80	9.2
P3-neutrasel 5227	Basic ingredients: neutralized carboxylic acids, phosphates. Amine-free, low COD product. Very good temporary corrosion protection also on cast iron.	L	spray	■	■	■	■	■	■	■	■	20	80	9.5

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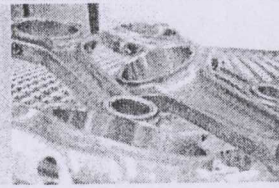

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Product	Short Description	Consistency	Application	Working Temperature °C		pH-value (1 % in DI-water)
				min	max	
Plastic Cleaners						
Plastiwash 1937	Basic ingredients: citric acids. Suitable for all types of plastics, recommended for conversion coating processes prior to painting. Phosphates-free.	L	spray	55	65	2.8
Plastiwash 1939-2	Basic ingredients: phosphoric citric acids. Suitable for all types of plastics, recommended for conversion coating processes prior to painting. Surfactant-free. Non foaming product.	L	spray	40	65	2.5
Plastiwash 8587-3	Basic ingredients: alkali hydroxides. Suitable for all types of plastics, recommended for conversion coating processes prior to painting. Surfactant-free. Non foaming product.	L	spray	45	65	11.4
Novarinse	Rinse aid, prior to painting especially for plastics.	L	spray	25	40	6.5
P3-upon 5800 [1]	Basic ingredients: phosphates and surfactants. Cleaner for the removal of heavy soils and greasy contamination as well as pigmented, fatty acid containing drawing compounds from steel in spray application.	L	spray	40	80	12.0

1) Steel/iron can be cleaned as well.

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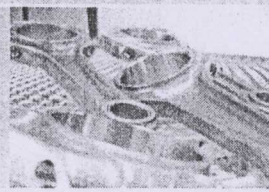

Product	Short Description	Consistency	Application	Working Temperature °C		pH-value (1 % in DI-water)
				min	max	
Surfactants/Inhibitors/Antifoam						
Globex Plus 09	To improve economically degreasing properties for spray systems. Less surfactant needed / lower COD, wide range application.	L	spray	40	60	7.0
Ingodes 41C	Basic ingredients: Nonionic surfactants. Defoamer, silicon-free.	L	spray/dip	40	80	7.0
P3-cronisol 673	Oil based defoamer, high efficiency, no influence on a follow-up painting process.	L		–	–	
P3-emalam 0469	Based on nonionic and anionic surfactants. Degreasing booster for alkaline and neutral immersion systems.	L	dip	–	–	7.2
P3-neutrapon 5003	Cleaning booster / surfactant additiv. Improves the cleaning performance of neutral cleaners, replenishing after centrifuging, ultrafiltration or similar processes.	L	spray	50	80	–
P3-tensopon 0510	Degreasing booster for neutral and alkaline dip / flood systems, good permeability on UF / MF membranes.	L	dip	–	–	9.7
P3-tensopon 0682	Demulsifier / antifoam, splitting of emulsions.	L	spray	–	–	6.5
P3-tensopon LF 0503 IT	Boosting the degreasing properties of spray systems. Contains solvent.	L	spray	30	60	–
P3-tensopon 0506 IT	High efficient cleaning booster. Contains solvent.	L	dip	40	70	–
Ridosol 1270	Basic nonionic surfactants. Suitable for all materials.	L	spray/dip	50	60	5.0–7.0
Ridosol 27 B	Basic anionic and nonionic surfactants. Suitable for all materials.	L	dip	50	80	5.0–7.0
Synergic 2900	Degreasing booster for alkaline solutions, contains solvents. Low foaming.	L	spray	–	–	4.2

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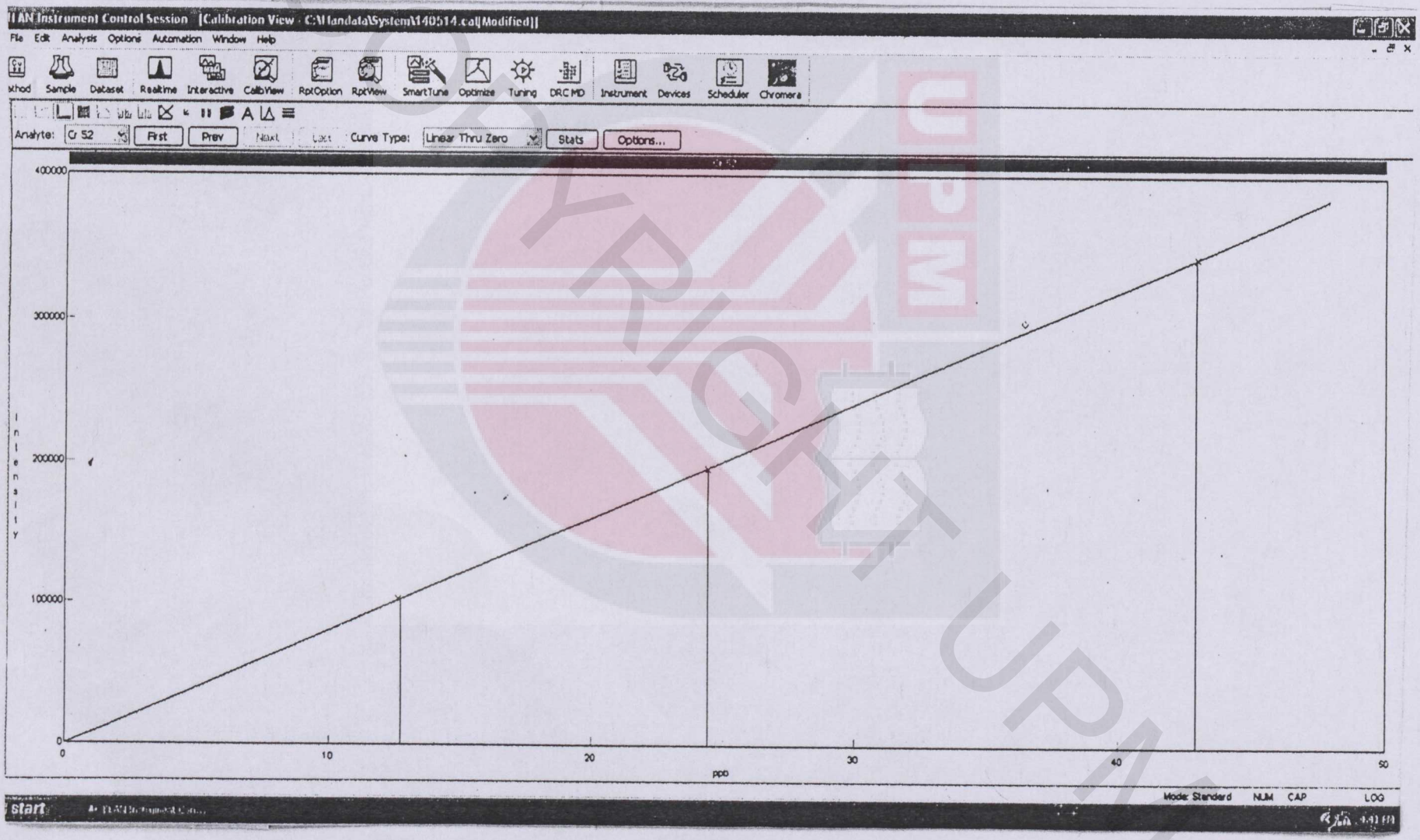
APPENDIX 6

Calibration Graph for Chromium and Nickel

ICP-MS GRAPH CALIBRATION FOR CHROMIUM



ICP-MS GRAPH CALIBRATION FOR NICKEL