Q8 Oils

engineers guide

to using metalworking fluids

Contents

Introduction

This guide is intended to provide users with information and advice on how to manage metalworking fluids (MWF). This includes both water miscible metalworking fluids (sometimes referred to as soluble) and neat metalworking fluids at every stage from 'cradle to grave'. It aims to give a broad understanding of cutting fluids, wire drawing and rolling emulsion management rather than attempting to cover every smallest detail. It concentrates on giving practical advice to users on how to get the best from their systems and how to avoid the mistakes which can be caused during the system design and product selection.

The guide also covers the essentials of maintenance and the monitoring of emulsions as well as giving you advice on what to do when things go wrong. You will also find recommended procedures for the safe waste disposal of water miscible metalworking fluid at the end of its useful life.

If you have any questions regarding any point in this guide, then please contact your local Q8Oils representative.

Terminology

This guide to metalworking fluids is written to be understood by everyone involved in the use, maintenance and management of neat and water miscible metalworking fluids, wire drawing and rolling emulsions. For those people with limited knowledge of these products and industry terminology, the following definitions may be helpful:

Bacteria

Microscopic, diverse single-celled organisms. They can be split into two main groups;

Aerobic bacteria - require Oxygen
Anaerobic bacteria - do not require Oxygen

Bactericide / Biocide

Chemical additive for controlling the growth of bacteria.

Biostable / Biostability

A property which means the fluid or compound demonstrates resistance to microbiological growth.

Conductivity

The measurement of a solutions ability to conduct electricity.

Corrosion inhibitor

A chemical compound which provides protection to the metal surface by reducing the rate of corrosion.

CFU

Colony forming units.

Dipslide

Sterile layer of agar used to determine the level of bacteria, fungi and yeast.

Emulsifier

A compound which reduces surface tension allowing non water soluble molecules such as oil to be suspended in water.

Terminology

Emulsion

Oil dispersed evenly at a controlled droplet size.

Extreme pressure additive

Commonly known as EP, provides a chemical, friction reducing film.

Fungi & moulds

Fungi and moulds are multi-celled organisms and large in comparison to bacteria (>2µm).

Fungicide

Chemical additive for controlling the growth of fungi.

LEV

Local exhaust ventilation.

MWF

Metalworking fluid.

pH

The measurement of acidity and alkalinity.

PPE

Personal protective equipment.

Refractometer

Instrument for checking the concentration or dilution of a metalworking fluid by light refraction.

SDS

Safety data sheet.

Tramp oil

Any leaking or lost oil (slide way, hydraulic or gearbox) present in a metalworking fluid.

Water miscible

A substance or product when added to water is either soluble to create a solution or results in a fine and uniform emulsion.

Yeast

Single celled fungi.

Security, safety, health and environment

Q8Oils is committed to Security, Safety, Health and the Environment. We conduct our business so that the safety and health of our employees, contractors, suppliers, customers and the community are assured. We measure and review our SSHE performance and set objectives and targets for continuous improvement.

Specifically, we work with the environment agencies to ensure full environmental protection at all our production facilities.

At Q8Oils we believe that;

- All occupational injuries and illnesses can be prevented.
- All operating exposures can be controlled.
- Training employees to work safely is essential.
- People are the most important element of the Safety, Health and Environmental programme.

We believe that it is good business to comply with best industry practice, and we operate a world class Security, Safety, Health and Environmental Management System (SSHEMS).

What the law requires

Your duty of care

The Health & Safety Executive (HSE) has identified that exposure to metalworking fluids can be hazardous to the skin, eyes and more critically to the airways and lungs, potentially resulting in serious respiratory diseases.

As an employer, you have a duty of care to take adequate measures to protect your operators from this exposure. This is enforced by law under The Control of Substances Hazardous to Health Regulations (COSHH) 2002.

You can achieve adequate control to exposure by:

- Carrying out a risk assessment and identifying measures to minimise exposure.
- Using the most appropriate product.
- Providing adequate local exhaust ventilation (LEV).
- Conducting and recording a fluid monitoring programme.

In addition COSHH also requires a suitable health surveillance programme for working with MWF covering both skin and lung disease.

Keeping records is an essential requirement of COSHH; this includes retaining any records of inspections or checks for 5 years plus any employee health records for 40 years.

Follow the HSE guidelines
www.hse.gov.uk/metalworking

Regional and national health and safety law may vary.

What the law requires

Keeping records in accordance to COSHH requirements;

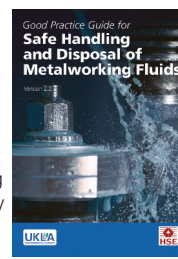
5 YEARS — Fluid monitoring checks & LEV maintenance

40 YEARS — Employee health records & records of exposure to hazardous substances

HSE guidelines for metalworking systems & products

We recommend that you keep up to date with the latest HSE (Health & Safety Executive) publications. www.hse.gov.uk/metalworking

In addition the United Kingdom Lubricants Association (UKLA) has published a useful 'Good Practice Guidance for Managing Metalworking Fluids'. This has been produced in partnership with the Health & Safety Executive (HSE), including HSE's Health & Safety Laboratory and leading MWF suppliers including members from Q8Oils.



If you have any queries regarding these publications and the new UKLA Good Practice Guide please contact the Q8Oils local representative.

Handling precautions for metalworking fluids

Inhalation risk

During machining metalworking fluid mist can form due to high pressure, agitation and high temperature. This provides a potential risk to health for operators exposed to this mist.

Inhaling MWF mist, which can contain hazardous substances such as tramp oil and micro-organisms, can increase the risk of lung disease, such as occupational hypersensitivity pneumonitis (OHP) and occupational asthma (OA). Symptoms such as persistent coughing recurrent chest infections, breathing difficulty and weight loss may be an early indication of developing a serious lung disease.

Operator exposure to MWF mist should be minimised by enclosing the work processes using LEV and mist filtration units. These engineering controls need to be maintained and checked on a regular basis.

A suitable health surveillance programme should be in place for allergic diseases such as OA or OHP. If an employee has unexplained respiratory symptoms it is essential that the occupational health provider is informed. Alternatively, the employee should seek advice from a qualified medical professional and explain that their symptoms may be work related.

Handling precautions for metalworking fluids

Risk to skin

Contact with metalworking fluids is in many cases unavoidable. All metalworking fluids can cause skin irritation or sensitisation but in many circumstances the risk of a skin irritation or sensitisation can be minimized. After working with metalworking fluids, wash your hands with a disinfecting soap and use a hydrating cream.

Skin irritation

Operating soluble products at too high a concentration often causes skin complaints. Metalworking fluid will de-fat the skin causing dryness and irritation. High levels of fine particulate swarf will abrade the skin leaving it more susceptible to irritation and infection. Ensure adequate filtration of the coolants.

Skin sensitisation

A serious condition where upon initial exposure, the skin becomes very sensitive to a chemical causing an allergic reaction. Subsequently this reaction can then reoccur at significantly lower levels of exposure to the chemical. Skin sensitisers are identifed by law on the SDS and hazard label, these can include certain types of biocides.
The correct PPE should always be used and any known operators known to be previously sensitised should avoid close contact with the chemical. If an outbreak occurs contact a hygiene specialist whom will carry out skin allergy tests to identify the chemical causing the problem.

Handling precautions for metalworking fluids

Recommended precautions

- Avoid direct skin contact with metalworking fluids.
- Ensure thorough skin hygiene practice.
- Do not clean hands in the metalworking fluid.
- Use after work moisturising creams.
- Avoid using compressed air.
- Wear oil-resistant protective gloves & clothing.
- Wear eye protection.
- Ensure adequate ventilation and local exhaust ventilation (LEV).
- Refer to supplier safety data sheet.

What are emulsions and fluids for metalworking, drawing and rolling?

Metalworking The most important functions of a metalworking fluid are to cool and to lubricate. These functions extend the life of the tool, reduce friction and flush chips and swarf from the cutting zone.

Drawing emulsion The most important functions of a drawing emulsion are to lubricate between the metal and the die, the metal and capstan and to extend the life of the die. The drawing emulsion also protects the capstan, cools surfaces and keeps the drawing machine clean by carrying fines to the filtration system.

Rolling emulsion The most important functions of a rolling emulsion are to cool the metal and work rolls whilst providing the required lubrication to the roll bite. In addition enabling the reductions required to protect the work rolls and mill surfaces from corrosion.

The more you understand about water miscible oils the better you will be able to manage them effectively and appreciate why precautions should be taken and procedures followed.

A water miscible metalworking fluid can be any of 3 basic types:

1. Conventional oil in water (milky type)
   Mineral oil which is finely dispersed into water by use of emulsifiers.
2. Semi-synthetic or micro emulsions (semi-transparent)
   Mineral oil and synthetic components very finely dispersed into water.
3. Synthetics or chemical solutions (transparent)
   Oil free emulsions or a true solution of water soluble additives.

Water miscible metalworking fluids typically contain

- **Mineral and/or synthetic oil (0-80%).**
- **Emulsifiers.**
- **Surfactants.**
- **Corrosion inhibitors.**
- **Lubricity additives.**
- **Extreme pressure additives (EP).**
- **Bactericides.**
- **Biocide.**
- **Fungicide.**
- **pH buffers.**
- **Antifoams.**
- **Metal protectives.**

Any one component can run out before the other causing an imbalance.

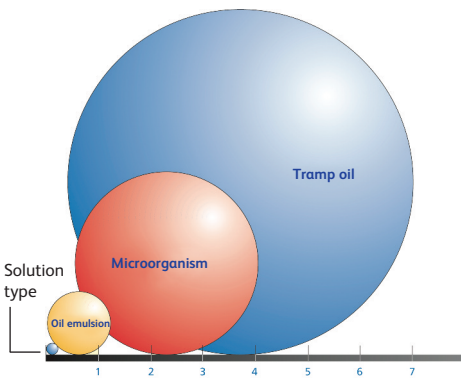
Neat metalworking fluids typically contain

- **Mineral and/or synthetic oil.**
- **Corrosion inhibitors.**
- **Lubricity additives.**
- **Extreme pressure additives (EP).**
- **Anti-oxidising agent/anti-oxidant.**
- **Antifoam.**
- **Anti-mist agent.**

The importance of droplet size

Water miscible metalworking fluids work more effectively when droplet sizes fall within the range 0.2 to 1.5 microns. The diagram shows the relative sizes of solution type and oil emulsion type fluid compared to an emulsion contaminated with micro organisms and tramp oil. This illustrates the need for regular monitoring and maintenance.

Comparative sizes



Emulsifiers

An emulsion is a mixture of two or more liquids that do not normally mix. One liquid becomes dispersed (the dispersed phase) in the other (the continuous phase), the boundary between the phases is called the "interface. An emulsifier is required to create this interface.

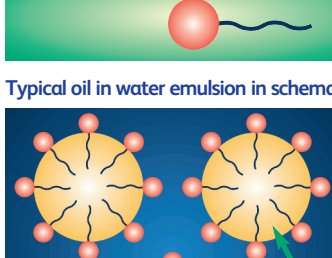
The properties and appearance of an emulsion vary enormously and depend on the nature of the two phases, the emulsifier, and how the two phases are mixed. This will dictate the droplet size and the stability.

Water mix metalworking fluids are designed to work as oil in water type emulsions. They will usually rely on more than one emulsifier to create a micro emulsion which are thermodynamically stable. It is however important to ensure the correct concentration, mixing and conditions to maintain the equilibrium of the emulsion.

Emulsifier additives

These enable water and oil to interact by polar interaction.

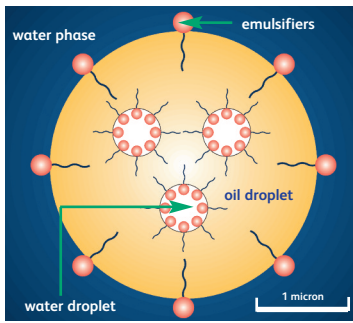
Typical oil in water emulsion in schematic format



An oil in water (o/w) emulsion occurs if the dispersed phase is a non-water (hydrophobic) material and the continuous phase is water or an aqueous solution. This type of emulsion is formed when a metalworking fluid concentrate is added to water & mixed correctly. Typically the smaller the oil droplet the more translucent the emulsion appearance and generally more stable.

Emulsifiers

Typical water in oil (invert emulsion)



A water in oil (w/o) emulsion occurs if the dispersed phase is water or an aqueous solution and the continuous phase is an organic liquid such as oil. This is sometimes referred to as an inverse emulsion.

This type of emulsion is formed when water is added to oil rather than following the recommended procedure. Note how water droplets are inside the oil droplet yet the water is still the continuous phase surrounding the oil. The final emulsion particle size is much larger and takes on a significantly different appearance and behaviour i.e. it will not perform the same as an oil in water emulsion.

Some common examples of emulsions include;

Oil in water (o/w) emulsion
- Homogenized milk - an emulsion of milk fat in water.
- Vinaigrette - an emulsion of vegetable oil in vinegar.
- Soaps and cosmetics.
- Water based paints.

Water in oil (w/o) emulsion
- Butter - an emulsion of water in butterfat.
- Margarine.
- Cosmetic creams and moisturisers.

Storage of metalworking fluids

It is important to manage the storage conditions for MWF to maintain quality and performance. For specific storage advice refer to the SDS section 7.

Q8Oils recommend that you always store water miscible oil concentrate and neat metalworking fluids indoors at a temperature above freezing.

Storing MWF concentrates

- MWF concentrate should be stored indoors (between 5 °C and 40 °C).
- If stored outside containers should be placed under cover to avoid exposure to moisture and extremes of temperature.
- If there is a risk of exposure to rain or condensation, either store upright with the lids covered, or on their side to prevent water collecting around the outlets.
- Maintain stock rotation to ensure that product is not stored longer than recommended.
- Do not use MWF concentrate beyond the expiry date.
- Ensure that hazard warning labels are visible on all storage containers.

Storing diluted MWF

- Do not exceed storage life or temperature recommendations.
- Storage tanks should be checked regularly to ensure they are clean.
- Perform microbiological testing on the diluted fluid prior to use and at least every month.
- If microbiological growth is detected then the diluted fluid should be treated with a biocide or disposed.

If in doubt, consult Q8Oils for advice about the conditions of storage and durability of diluted stocks.

Mixing of metalworking fluids

The mixing process can affect the long term stability of a metalworking fluid emulsion.

- Always add concentrate to water to avoid instability.
- Never add water to concentrate, as this can cause an invert emulsion.
- Refer to Q8 Product Data Sheets for mixing instructions.

It is recommended that you use a mixer unit or dosing unit that is specifically designed for water miscible fluids.

The Dosatron type is a water pressure powered model, which stops when demand is zero. It is positive displacement, which gives a constant mixture over a wide temperature range and flow rate and is easily adjustable.

Venturi mixers are effective and much less expensive, but are not as reliable in the long term as positive displacement type of mixer units.

Water

The water quality should be known in order to avoid problems arising from fungal and bacterial growth, extreme pH and high mineral salt content. Mineral salts naturally occur in water but the content can vary significantly depending on the source. These commonly include; calcium, magnesium, sodium, bicarbonate, sulfate, chloride and nitrates. At high levels any of these can affect the quality of the metalworking fluid.

One key factor affecting the metalworking fluid is amount of calcium and magnesium carbonates which dictate the water hardness. This can vary significantly from one region to another and season.

Your local water authority can supply you with further details regarding water quality.

The water used for water miscible metalworking fluids should be clean and pH neutral. Water should not be too hard or too soft (see table below) as this can cause precipitation or foaming. Too soft water can be hardened with additives and too hard water should be demineralised prior to mixing.

The water hardness can be expressed in various units of measurements but most commonly used is ppm (parts per million) $CaCO_3$/L or Kg or in German degrees (°dH).

Classification	hardness in ppm or mg-$CaCO_3$/L	hardness in °dH (German degrees)
Soft	0 - 60	0 - 3.4
Moderate / medium	60 - 150	3.4 - 8.4
Hard	150 - 250	8.4 - 14.0
Very hard	≥ 250	≥ 14.0

1 Degree Hardness German Scale = 17.8 ppm as $CaCO_3$
1 Degree Hardness French Scale = 10 ppm as $CaCO_3$
1 Grain per US Gallon = 17.1 ppm as $CaCO_3$

Engineering controls and system design

Various control measures can be implemented to ensure that processes using metalworking fluids remain efficient and reduce health risks to operators.

These include;

- Control measures on machines & processes
- Effective design and provision of LEV and mist filtration systems.
- Avoid using compressed airlines for removing MWF where practical.
- Provision of appropriate PPE.
- Provision of information, instruction and training to employees.

Control measures on machines & processes

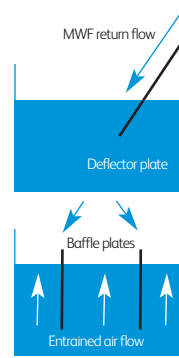
Where practical consider the following measures;

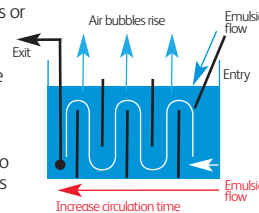
- Enclose machining processes to reduce operator exposure.
- Add in time delays before opening machine doors to allow mist to clear.
- Ensure fluid volume, rate of flow, temperature are all set appropriately.
- Ensure pipe dimensions (width and height from fluid) and filtration are appropriately set.
- Consider other operational controls such as breakers to increase circulation time to reduce the propensity of foaming.

Engineering controls and system design

Machine sump design

- Install a deflector plate to minimise air entrainment by slowing free falling fluid from the return flow.
- Install baffle plates to encourage entrained air within the fluid to reach the surface rapidly and prevent re-entry into the pump system.
- Ensure machine sump pumps are positioned at the opposite end to the fluid return flow. This will help prevent dead areas or zero flow conditions. The pump should be the self-priming positive head suction type.
- Ensure sump tank has adequate accessibility to ensure future cleaning is easy as possible.





Engineering controls and system design

Filtration

It is important to implement effective and efficient filtration as part of the process of machining and recirculating metalworking fluids.

During machining metalworking fluids are subject to a large assortment of contamination from the process and the environment. These include; metal chips and fines, airborne contamination and oil from machine leaks. Where possible these contaminants should be removed from the metalworking fluid to ensure it continues to perform to its optimum and reduces premature ageing of the fluid.

Positive filtration implies the use of filter media such as porous cloth, paper or wire screens to remove solid matter, such as swarf and fines from the fluid. This can be in combination with pressure or vacuum.

Positive filtration

Method	Description	Advantages	Disadvantages
Gravity filters	Relies on the weight of the metalworking fluid passing through the filter media (paper, cloth, wire). Usually a belt or conveyor moves the media away and exposes a clean section.	Easy to operate, initial cost is low.	Disposable media required. High foam fluids can result in excessive media usage.
Pressure filters	Consists of a filter unit, settling tank and a drag out chain. The fluid is forced through the filter media.	Removes swarf efficiently. Can handle large fluid volume.	Disposable media usage can be high. Excessive tramp oil can lead to plugging of the media.

Engineering controls and system design

Positive filtration (continued)

Method	Description	Advantages	Disadvantages
Vacuum filters	A fluid tank with filtering chamber at the bottom covered with either disposable or permanent media. As the cake (filtrate) increases a resistance to flow causes a vacuum which activates a conveyor moving the media to discharge.	Initial cost is low and filtration is efficient.	Requires higher floor space. Not suitable for cast iron grinding.
Tube filters (cartridge)	Fluid flows up the inside of the tubes by pressure or vacuum. Diatomaceous earth is often used as filter media.	Extremely efficient, high cleanliness can be achieved.	Expensive and mostly suited to synthetic fluids.

Other methods such as separation systems can be employed to aid the removal of contaminates;

Separation methods

Method	Description	Advantages	Disadvantages
Settling tanks	The simplest type of filter system where a modification of the machine sump allows swarf to settle to the bottom.	Low cost and inexpensive to operate and maintain as no media is required.	Only suitable for large tanks. Less effective for small particulates such as cast iron.
Multiple weir	A series of troughs or metal tubes arranged in parallel. Fluid feeds into a 'dirty' compartment where fines and free oil are mechanically skimmed from the surface. Clean fluid is delivered to the 'clean' compartment.	Very efficient and effective on smaller particulates such as cast iron. Relatively inexpensive and simple as no media is required.	Weirs can provide a surface for fungal growth.

Engineering controls and system design

Separation methods (continued)

Method	Description	Advantages	Disadvantages
Magnetic separators	Used to remove ferrous swarf (iron particles) by attraction to a magnetized surface. Clean fluid is returned to the machine as ferrous particles are captured.	Low maintenance. Very efficient. Minimal floor space required.	Limited to the removal of magnetic material (ferrous) only.
Centrifuge	Used in combination with positive filtration (ie porous media) to remove oil and small fines. Fluid is subject to centrifugal force (high speed spinning) in a bowl which pushes particulates to the outside. Clean fluid passes over the top and returned to the sump.	Excellent for small fines and tramp oil.	Cannot handle a large quantity of fluid due to the low flow rate.
Cyclone	A settling tank allows large particulates to settle to the bottom as the partially clean fluid is pumped to a cone shaped cyclone filter. The fluid is subject to high force which separates the particulates and delivers clean fluid back to the machine.	Simple and easy to use. No disposable media.	Relatively higher costs. Large particles must be removed first to prevent clogging of cyclone.

Engineering controls and system design

Effective design and provision of LEV and mist filtration systems

It is essential that adequate LEV is installed and operated to remove MWF mist from machine enclosures. These also need to be checked & maintained on a regular basis to ensure they are fully operational. A thorough examination of LEV systems must be carried out at least once every 14 months by a competent ventilation engineer.

** Geographical variations may apply*

Avoid the use of compressed airlines

The use of compressed air on machined components is proven to increase the risk for inhaling MWF mist and splash contamination of skin and clothing. Alternative methods should be considered, such as enclosed component cleaning systems fitted with LEV, vacuum lines, absorbent materials, or degreasing/washing methods. Where these are not practical other measures can reduce the risk such as reducing the airline pressure, increase the distance of the airline and operator using a longer nozzle or using airlines fitted with shields to minimise splash back.

Engineering controls and system design

Photographs of a mannequin contaminated with MWF on the torso and face following the use of a compressed airline. (Source HSE RR904 Research report (2011).

Provision of appropriate PPE

It is essential that the appropriate PPE is available and used at all times when machining and using metalworking fluids. This can include gloves, glasses, overalls & footwear.

Guidance on using the correct PPE is available from the HSE www.hse.gov.uk/pUbns/indg330.pdf

Maintenance of metalworking fluids

Neat metalworking fluids

In general, neat metalworking and drawing oils are easier to maintain than water miscible fluids. Neat metalworking fluids should be free of solids and maintained at the original viscosity. Contamination with 'tramp oils' like hydraulic oils should be avoided. These contaminants can influence the viscosity and additive level to such a degree that the performance of the neat metalworking fluid can reduce.
Q8Oils has neat metalworking fluids which are dual-purpose e.g. metalworking fluid and hydraulic fluid. For these products contamination will not change the metalworking performance.

Water miscible metalworking fluids

Water miscible metalworking fluids are prone to infection such as bacteria, fungi or yeast. They can deteriorate, causing them to smell, split and separate. It is important to recognise that once in use the composition of the metalworking fluid emulsion can change, this can include both chemical and microbiological contamination.

This can result in potential hazards to the skin, eyes and respiratory system.

To protect YOU and your metalworking fluid preventative measures are required.

THIS WILL SAVE MONEY AND CREATE A SAFER WORKING ENVIRONMENT

Good practice and maintenance of metalworking fluids

These measures will help you optimise operating conditions ensuring efficiency and a safer working environment.

General

- Refer to the Safety Data Sheet & conduct a risk assessment.
- Regularly check for dermatitis and respiratory problems and report symptoms promptly.
- Provide training and instructions for employees in the safe use of MWFs and correct use of Personal Protective Equipment (PPE).
- Use PPE when handling MWFs and when cleaning out machines.
- Follow manufacturer's guidelines when using MWFs, biocides and system cleaners

Machine operation and engineering controls

- Provide and maintain local exhaust ventilation (LEV).
- Allow a time delay before opening machine enclosures.
- Ensure correct MWF flow and delivery.
- Use machine guards and spray covers properly.
- Observe good personal & factory hygiene.
- Avoid using compressed air.
- Keep the MWF tank covered.
- Use filters to remove swarf and fines.

Fluid maintenance

- Ensure personnel responsible for MWF maintenance are trained.
- Conduct and record regular monitoring of MWFs and take actions where results are not within recommended tolerance levels.
- Mix MWFs and top-up sumps correctly.
- Remove contaminants as soon as possible, ensuring workers understand that the sump must be a waste free zone.
- Remove tramp oil regularly using appropriate equipment. Tramp oil should not exceed 2% contamination.

Good practice and maintenance of metalworking fluids

Fluid maintenance (continued)

- Sterilise the system using System cleaner before introducing fresh emulsion. Avoid using contaminated water.
- Select bio-stable fluids.
- Use biocide where appropriate (as a preventive measure), Q8Oils can advise.
- Keep within the specified recommendations for the concentration;

Too low concentration promotes:
- Microbiological growth.
- Lower emulsion stability.
- Lower cutting performance.
- Accelerates corrosion problems on machine and metal.

Too high concentration can cause:
- Foaming.
- Less cooling.
- Poor tool performance.

- Keep within the specified recommendations for the pH;
  - A drop in pH maybe caused by bacteriological contamination. This can subsequently encourage further bacterial growth. This can result in an unpleasant odour and the emulsion can become unstable.
  - A significant rise in pH can be attributed to the presence of alkaline or system cleaners.

Condition monitoring techniques

Neat oil condition monitoring

Normally, the monitoring of neat metalworking fluids is simple, as microbiological growth is low and the fluid life time is long.

Neat metalworking fluids should be monitored on:

- Viscosity.
- Contamination.
- Additive concentration.
- Oxidation.

Water miscible condition monitoring

Water miscible fluids however require more monitoring and regular measurement of;

- Visual check of oil float, surface creaming, & watery layers.
- Odour.
- Concentration by refractometer.
- Contamination level of micro-organisms.
- pH value.
- Conductivity.
- Water hardness.

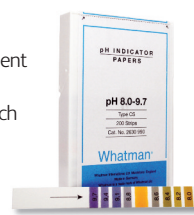
For more specific monitoring techniques or complex testing you can contact Q8Oils or a specialised laboratory.

Condition monitoring of metalworking fluids

Instruments required or recommended for maintaining metalworking fluids

- **Essential**
  - Refractometer
  - pH papers or pH meter
  - Dipslides and incubator

- **Beneficial**
  - Conductivity meter
  - Water hardness test kit
  - Thermometer



- **Specific**
  - Wire drawing Co-efficient of friction
  - Rolling emulsion quench characteristics

Condition monitoring

Measuring the concentration using a refractometer

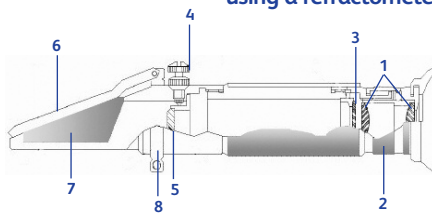


Figure 1. Refractometer schematic

1. Eyepiece	**5. Lens**
2. Scale focusing	**6. Plastic cover**
3. Scale	**7. Prism**
4. Scale calibrating	**8. Frame for plastic cover**

A refractometer is a handheld optical instrument that can be used to measure the mixed concentration of soluble metalworking fluids. The refractometer gives a number by measuring the refractive index of the fluid mixture. The operator can then monitor the concentration of the soluble metalworking fluid.

Calibration

Calibration of the refractometer is necessary to obtain an accurate refractive index measurement. Before calibrating the instrument, ensure that the temperatures of the refractometer, water and soluble metalworking fluid sample are at ambient temperature, as accurate calibration is temperature dependent.

Proceed as follows:

Place a few drops of water (used for the mixture) between the plastic cover (6) and the prism (7). Hold the refractometer horizontally and point it at a light source. Look into the eyepiece (1) and adjust the scale calibrating knob (4) until the boundary line which separates the light and dark areas of the scale is aligned with the zero line on the scale. Figure 2 depicts a typical refractometer scale.

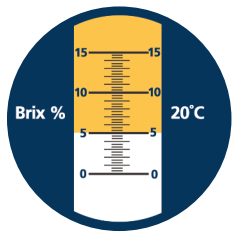


Figure 2. A typical refractometer scale

Instructions for use

1. Lift the plastic cover and dry the prism with a clean, dry cloth. Place one or two drops of the fluid on the prism and close the plastic cover.

2. Note the refractometer scale reading at the point where the boundary line separates the light and the dark areas on the scale. Determine the concentration by multiplying the refractometer scale reading by the refractometer factor of your soluble metalworking fluid (see note & example).

3. Clean the refractometer prism and plastic cover with a dry, clean cloth before storing the refractometer in the carrying case.

Note:
Metalworking fluid concentration (%) = refractometer X factor

Example:
The refractometer factor for Q8 Brunel XF 343 = 1.25
A 5.0 reading on the refractometer scale, as seen in Figure 2 multiplied by the refractometer factor of 1.25 yields a 6.25% concentration of product.

Condition monitoring

Measuring the pH

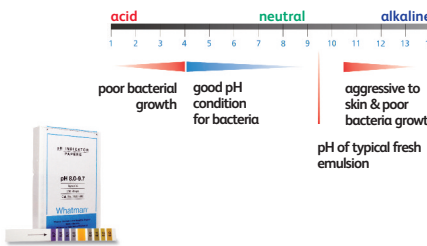
pH papers

Dip the indicator strip into the liquid to be tested for a few seconds.

Remove the strip from the test solution and compare the resultant colour with the colour segments printed on the strip.

Important
Do not store indicator papers where they are liable to be exposed to acid or alkaline gasses or vapours.

the pH scale



Water hardness papers

This is most commonly measured using water hardness test strips and kits that can be obtained from a variety of manufacturers with instructions on how to use them. Test strips provide a reading expressed as a degree or parts per million (ppm) of calcium carbonate ($CaCO_3$) content which represents water hardness.

Condition monitoring

Conductivity

The electrical potential of a fluid is measured in siemens, most often in microsiemens (µS) or millisiemens (mS). This indicates the amount of electrolytes in solution.

An electrolyte is a substance that dissociates into its ions in solution and acquires the capacity to conduct electricity. Examples include sodium, potassium, chloride, calcium, magnesium, and phosphate.

Typical conductivity values of water; (at 25°C)

- High quality deionized water 5.5 µS/m.
- Typical drinking water 50–500 µS/m.
- Sea water 5 million µS/m (i.e., conductivity of sea water is approx. one million times higher than that of deionized water).

Measuring conductivity can be useful when used in conjunction with other data as it can indicate the build-up of salts which may relate to the effect of aging on the metalworking fluid. It is a particularly useful test in hard water areas to indicate hard water salt build up, where problems can be encountered above 3,000 µS.

Excessively high conductivity can also increase the risk of corrosion problems.

Condition monitoring

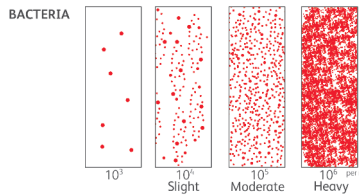
Monitoring microbiological contamination

All water containing fluid systems can become prone to microbiological growth. The use of dipslides is the method most frequently used to measure and observe microbial activity in liquid-based systems. A dipslide contains a sterile layer of agar on both sides which is used to determine the growth of bacteria, fungi & yeast, measured as colony forming units (cfu/cm^3).

Method for using dipslides to monitor microbiological growth

1. Wash your hands and use disposable single-use gloves to handle the dipslide and MWF sample.
2. Remove the dipslide from the tube being careful not to allow the agar on each side to hit the edge of the clear plastic tube.
3. Place the dipslide directly into the sample being tested making sure the dipslide agar is fully submerged for approximately 10-15 seconds.
4. Place the dipslide into the sterile plastic tube taking care not to damage the agar.
5. Place the dipslide tube into a dipslide incubator. The temperature and duration of the incubation period will vary depending on the type of dipslide refer to specific supplier instructions. Generally results are readable after 48 hours of incubation for bacteria and 3-5 days for fungi.
6. Compare the number of colonies of bacteria, fungi or mould on the dipslide against the comparison chart provided by the dipslide manufacturer. Note that usually one side will indicate if bacterial growth is present in the form of red spots. The other side will contain agar specific to fungi & yeast. The supplier's chart will provide you with an estimate of the CFU/ml.

Monitoring microbiological contamination



Taking action against infected MWF

Action is required where results indicate levels consistently above 10^4 cfu/ml; this will include chemical additions to eliminate the presence of bacteria, or a full system clean down and recharge.

1. Ensure that all good practice checks and actions are being applied to maintain the quality of the MWF (concentration, pH, tramp oil content, metal contamination, operating temperature, agitation and flow).
2. If after applying these measures the growth of bacteria, yeast and fungi remain high, the addition of a suitable biocide may be required at the recommended dosage based on the sump volume.
3. When using biocides always follow the supplier's recommended dosage & refer to the SDS for advice about handling requirements & PPE.
4. Add biocides into the sump system to ensure that adequate mixing with the MWF is achieved.
5. Ensure that all additions of biocide are noted and records are kept.
6. Do not overuse biocides as this may cause dermatitis and asthma, overuse may increase the risk of developing biocide resistant micro-organisms.
7. Immediate actions are required if the MWF is heavily contaminated with bacteria above 10^6 cfu/ml which may require disposal of the MWF and a complete system clean.

Treatment of infected metalworking fluids

Bacteria & fungal infections

The vast majority of bacteria and fungal infections which occur in coolant systems are non-pathogenic (not harmful to humans). However it has been demonstrated that aerosol mists of coolant contaminated with micro-organisms can cause respiratory reactions from the by-product produced from the organisms. Adequate control is therefore necessary.

The use of controlled dosing of biocides is one of the most effective methods should a system become infected.

Fungal infections once established are difficult to eradicate. One-off treatments are often unsuccessful as the fungal spores lie dormant waiting to re-infect. The regular use of an effective fungicide is normally required after the physical removal of all slimes and growths from all parts of the system.

For further information consult Q8Oils.

Cleaning procedure for machine coolant systems

Disposal of metalworking fluids

When a metalworking fluid requires disposal careful handling is required to account for the build up of metal and non-metal contaminants.

A neat metalworking fluid should be changed if:

- Contaminants cannot be removed.
- Tool life drops.
- Filtering becomes difficult.
- Odour problems arise.
- Excessive fluid ageing due to oxidation.

A unstable water miscible metalworking fluid should be changed if:

- High consistent level of bacteria.
- Visible signs of microbial growth ie biofilm and/or fungi.
- Significant pH change.
- Visible signs of emulsion ageing, high surface oil, difficult to read refractometer.
- Consistent tool life failure.
- A sudden increase in corrosion of parts or machine.

Cleaning procedure for water miscible metalworking fluids

This procedure should be carried out on existing machines with water miscible metalworking fluids to prevent bacterial infection and metal fines contaminating the fresh fluid.

The procedure, when followed, will provide a clean system enabling you to see the best performance from your fresh fluid. If the system is badly infected and a system cleaner is being used, add a kill dose of an effective broad spectrum biocide directly into the sump. This can be added 48 hours prior to the machine cleanout taking place.

1. Add the recommended percentage of system cleaner to the previous fluid up to 48 hours before disposal and cleaning of the machine - please make sure that the fluid is circulating around the machine even when the machine is not being used.

2. After treatment with system cleaner remove the fluid.

3. Place enough water into the system to enable pumping and circulate the water for a few minutes, this will flush out all residual system cleaner This water must also be treated as waste. Repeat until flushings are pH neutral.

Please note that if all the cleaner is not removed, foaming may be evident during start up.

4 Recharge the system with new coolant at the required concentration/dilution and measure with a refractometer to confirm concentration.

5 Leave some space in the sump for any adjustment required to the concentration.

Cleaning procedure for neat metalworking fluids

For systems which contain neat metalworking fluids the procedure of cleaning the system is easier than the cleaning of the water miscible fluids as the addition of the system cleaner is not required.

1 Dispose the old fluid correctly.

2 Clean all pipelines, tanks, nozzles, etc. thoroughly, remove swarf and fines.

If you are in any doubt, contact your Q8Oils representative. Q8Oils has a more detailed cleaning procedure available for you.

Disposal

At the end of its useful life, a metalworking fluid requires careful handling since it is considered as hazardous waste.

- The cost of removing hazardous waste can be expensive and is only likely to increase.
- The type of waste and volume will have significant influence on the cost.
- It is important to use only licensed or registered waste disposal organisations.
- All disposal should be carried out in accordance with your local and national legislation.

Before proceeding with disposal, it is important to consider the following factors

- Consider any toxic metals that may have accumulated.
- Consult your local water authority, as there are regional variations on the limits of certain waste materials.
- Can the waste be treated to make it less hazardous.
- Consider what equipment can be used to save cost in the long term.

Disposal

Legislation governing the disposal of waste metalworking fluids

There is a legal requirement for all companies to take measures to ensure the safe collection and disposal of waste oils.

Note that discharges to surface waters and of point source sewage effluent are subject to the Environmental Permitting Regulations and form part of the Environmental Permitting Charging Scheme.

There are key elements that will define the hazard of the waste.

For a full description of these methods, refer to the UKLA best practice guide for the disposal of water mix metalworking fluids.

http://www.ukla.org.uk/wp-content/uploads/UKLA-HSE-Good-Practice-Guide-for-Safe-Handling-and-Disposal-of-Metalworking-Fluids.pdf

Volume of waste MWF generated.	*This can be greatly influenced by careful fluid management.*
COD (Chemical Oxygen Demand).	*Measure of contamination of water by tramp oils and many other chemical compounds such as detergents, surfactants, biocides and anti-corrosion agents found in MWFs.*
BOD (Biological Oxygen Demand).	*Measure of how quickly micro-organisms use up the oxygen in water.*
TSS (Total Suspended Solids).	*Measure of suspended solids in water which include a wide variety of particles from the work pieces and other objects found in waste MWFs.*

Disposal

Fluid waste treatment

There are various methods that can be used to treat the waste MWF in order to reduce the hazard making it easier to dispose.

1. Primary treatment

Separation of the waste into two waste streams categorised by hazard level e.g. Tramp oil and suspended solids. Equipment can be used to achieve this during the life of the metalworking fluid thus reducing the hazard level of waste fluid and maintaining the attributes of the metalworking fluid.

2. Secondary treatment

Separation of the emulsified oil from the spent MWFs. This can significantly reduce the Chemical Oxygen Demand (COD) and may reduce the Biological Oxygen Demand (BOD) of the water component.

If the Total Suspended Solids (TSS), COD and BOD are within acceptable levels it may be possible to dispose of the water component as waste water with correspondingly low charges.

3. Tertiary treatments

This involves further treatment on the waste water to reduce the COD level even further so that the water can be re-used in non-critical processes.

Disposal

Summary of waste treatment processes

Treatment	Process	Function
Primary	Skimmers	*Floating tramp oil.*
	Oil absorbent pillows	*Dispersed tramp oil.*
	Settling tanks	*Metal and high-density particulates.*
	Magnetic separators	*Ferrous metal particulates from 50 -100 µm.*
	Hydro cyclones	*All particulates from 50 -100 µm.*
	Microfiltration equipment	*All particulates from 50 -100 µm.*
	Chemical coalescing	*Emulsified tramp oil agents and all particulates from 50-100 µm.*
	Flotation (air induced)	*Floating tramp oil and less-dense particulates from 50 -100 µm.*
	Centrifuges	*Tramp oil and particulates.*
Secondary	Chemical treatment	*A chemical agent is used to split the emulsion into oil and water phases. The recovered water may be acceptable for discharge as trade effluent and the oil phase disposed of by a licensed contractor as hazardous waste.*
	Evaporation	*Spent MWF is heated in special evaporating vessels to drive off water, leaving a reduced volume for disposal as hazardous waste.*
	Ultra-filtration	*MWF is passed through a membrane under pressure. Tiny pores in the membrane allow water through but oil and surfactants are retained.*
	Biological treatment	*Microorganisms are added to a bioreactor containing spent MWFs to reduce organic and inorganic materials. The treated water may be acceptable for discharge as trade effluent.*
Tertiary	Reverse osmosis	*Removal of dissolved matter including metal ions.*
	Nano-filtration	*Uses semi- porous membranes to remove metal ions and organic matter.*
	Carbon adsorption	*Activated carbon used to adsorb components from the fluid.*
	Ion-exchange resin	*Use to remove dissolved metal salts in the used metalworking fluid.*
	Ultra-filtration / Reverse osmosis	*MWF is passed through a membrane under pressure. Tiny pores in the membrane allow water through but oil and surfactants are retained. The water is also then passed through a reverse osmosis unit.*

Metalworking fluid - trouble shooting guide

Excessive misting	Concentration	*Adjust and maintain concentration at recommended dilution. Use a refractometer to measure the concentration.*
	Temperature	*Ensure temperature of the fluid is not too high.*
	Speeds, feeds, pump pressure and system design	*Ensure optimum fluid delivery for process but not too excessive to result in the generation of mist.*
	Tramp oil	*Remove tramp oil using a skimmer or by vacuum.*
	Extraction/ ventilation	*Ensure adequate LEV is in place and is working effectively. Maintain LEV service schedule.*
	Machine operation	*Allow a 'time gap' before opening machine doors to reduce the exposure to mist.*
	Fluid instability	*Check, monitor and maintain the stability of the metalworking fluid.*
	Foam bubble break	*Check condition of the fluid, and speeds and feeds are set correctly. Ensure adequate extraction is in place and working correctly.*

For Wire Drawing and Rolling applications please consult Q8Oils

Metalworking fluid - trouble shooting guide

Corrosion	Concentration	*Adjust and maintain concentration at recommended dilution. Use a refractometer to measure the concentration.*
	Poor water quality	*Use good quality water. Consider using deionised water.*
	High temperature/ humidity	*Reduce temperature and humidity and/or use a rust preventive such as Q8 Ravel range on finished parts.*
	Contamination	*Identify and eliminate contaminants that promote corrosion, such as salts, floor cleaners, tramp oil and bacteria.*
	Low pH of MWF	*Increase pH with small additions of a suitable pH buffer*
	Part handling/ storage	*Use clean, plastic dividers to allow parts to dry and remain separate. For extended storage, use a rust preventative such as Q8 Ravel on finished parts.*
	Unstable or MWF out of shelf life	*Keep stock within product shelf life. Check last time machine was cleaned.*

For Wire Drawing and Rolling applications please consult Q8Oils

Metalworking fluid - trouble shooting guide

Excessive foaming	Concentration	*Adjust and maintain concentration at recommended dilution. Use a refractometer to measure the concentration.*
	Contamination	*Identify and eliminate contaminants that promote foam, such as system cleaner residue, floor cleaners, phosphate parts cleaner etc.*
	Water quality	*Soft water (less then 100ppm total water hardness) can promote foaming. Consider using a metalworking fluid designed for soft water and / or an addition of suitable antifoam.*
	Type of operation	*Some operations, such as through tool technology can promote foam. Consider machine design and allow longer circulation time for MWF to deaerate.*
	Fluid level low	*Keep the sump full in order to maximise fluid retention time in sump and allow the air to be released out of the mix.*
	Machine design	*Check the filtration system, fluid delivery, and fluid return systems for mechanical problems or leaks and repair. Consider using breakers and wider diameter pipework to increase circulation time of fluid and minimise agitation.*

For Wire Drawing and Rolling applications please consult Q8Oils

Metalworking fluid - trouble shooting guide

Unstable emulsion	Concentration	*Adjust and maintain concentration at recommended dilution. Use a refractometer to measure the concentration.*
	Product shelf life	*Keep stock within product shelf life. Do not use if expired without checking with the supplier.*
	Exhausted metalworking fluid	*Check when the fluid was last changed and machine cleaned. If this recommended period has expired schedule a fluid change.*
	Contamination	*Identify and eliminate contaminants that promote mix instability, such as tramp oils, floor cleaners etc.*
	Water quality	*Hard water (greater than 200 ppm Total Hardness) can promote instability in some metalworking fluids. Consider using soft or deionised water. Alternatively use a hard water tolerant metalworking fluid.*
Poor surface finish	Concentration	*Adjust and maintain concentration at recommended dilution. Use a refractometer to measure the concentration.*
	Water quality	*Hard water (greater than 200 ppm Total Hardness) can promote instability in some metalworking fluids and lead to poor surface finish. Consider using soft or deionised water.*

For Wire Drawing and Rolling applications please consult Q8Oils

Metalworking fluid - trouble shooting guide

Poor surface finish	Unstable emulsions	*When MWF emulsions become unstable, their performance can be inconsistent due to additive depletion leading to a reduction in tool life.*
	Poor coolant flow	*Clear any blockages within the metalworking fluid delivery system. Consider treating with system cleaner to remove debris and biomass.*
	Incorrect tool for operation	*Check with tool supplier for the correct type.*
Poor tool life	Concentration too low or too high	*Adjust and maintain concentration at recommended dilution. Use a refractometer to measure the concentration.*
	Contamination	*Identify and remove contaminants that promote loss of tool/wheel life, such as high levels of tramp oils, floor cleaners etc.*
	Water quality	*Hard water (greater than 200 ppm total hardness) can promote mix instability in some metalworking fluids and lead to loss of tool/wheel life. Consider using soft or deionised water. Alternatively use a hard water tolerant metalworking fluid.*
	Fluid instability	*When MWF emulsions become unstable, their performance can be inconsistent due to additive depletion leading to a reduction in tool life.*

For Wire Drawing and Rolling applications please consult Q8Oils

Metalworking fluid - trouble shooting guide

Poor tool life	Fluid flow	*Check fluid flow is correct and is unhindered.*
	Wrong tool	*Check with tool supplier for correct type and use the appropriate metalworking fluid for the operation.*
Suspected micro-biological contamination	Obnoxious odour & presence of slime	*Check for bacterial contamination using dipslides and follow the correct procedure to eliminate or reduce.*
	Concentration too low	*Adjust and maintain concentration at recommended dilution.* *Use a refractometer to measure the concentration.*
	Fluid circulation	*Keep fluid circulating to prevent anaerobic bacteria.*
	Tramp oil	*Tramp oil can promote microbiological growth. Maintain machines and sumps to minimise tramp oil using a skimmer or by vacuum.*
	Confirmation of high bacteria contamination	*Treat the fluid with an appropriate biocide. If high contamination levels persist use a system cleaner before re-charging the system with fresh metalworking fluid.*

For Wire Drawing and Rolling applications please consult Q8Oils

Metalworking fluid - trouble shooting guide

Suspected micro-biological contamination	Confirmation of high fungal contamination	*Treat the fluid with an appropriate fungicide. All visible fungal mats should be physically removed from sumps and pipework where possible. If high contamination levels persist use a system cleaner before re-charging the system with fresh metalworking fluid.*
Residue	Incorrect concentration	*Adjust and maintain concentration at recommended dilution. Use a refractometer to measure the concentration.*
	Contamination	*Identify and eliminate/ minimise contaminants that promote residue, such as tramp oils, floor cleaners, fungal growth, etc.*
	Water quality	*Hard water (greater than 200 ppm Total Hardness) can promote residue in metalworking fluids. Consider using soft or deionised water or alternatively use a hard water tolerant metalworking fluid.*

For Wire Drawing and Rolling applications please consult Q8Oils

QCare

Technical services and support for metalworking fluids & industrial lubricants

QCare

QCare - expert technical support from Q8Oils

Q8Oils offers a range of world-class metalworking fluids which are designed to meet the high demands of modern machining operations and deliver top performance, while protecting the environment and operators' health.

To help you get the most out of these products, Q8Oils provides comprehensive technical support through our QCare service. This includes the following:

Application Specialists

Our experienced application specialists are on hand to offer you advice and guidance.

They help you select the most appropriate metalworking fluid for your application, which balances efficiency and safety. Using our Fluid M8 programme they can help you optimise performance through condition monitoring of the fluid in the machine and recommend any corrective actions. They also offer advice on working safely with metalworking fluids and complying fully with local and international health and safety regulations.

With their support, you can increase the life of your fluid, optimise performance, minimise unscheduled maintenance and reduce machine downtime.

The combination of highly trained Q8Oils Industrial Application Specialists and Fluid M8 will enable you to:

streamline your metalworking operation

significantly reduce operating costs

increase tool life

improve production rates

reduce coolant usage

improve operator acceptability

QCare

Equipment solutions

The equipment used with metalworking fluids is often overlooked and this can have an impact on safety. Choosing the correct equipment can reduce waste generation and cut costs. It is also important for manufacturers who are working to implement environmental management systems such as ISO14001 and OHSAS 18001.

Q8Oils has a comprehensive inventory of equipment solutions, backed by advice from dedicated technical experts, to help optimise the efficiency of your operations.

We can recommend and supply equipment suitable for monitoring and maintaining MWFs, from mixing units to fluid recycling systems. Whatever your requirement, we have a solution.

Training seminars

Q8Oils offers a range of training seminars, each run by an experienced Q8Oils technical specialist, to help you work safely and efficiently with metalworking fluids.

Our seminars include:

- Introduction to metalworking fluids
- Guide to working safely with metalworking fluids
- Equipment solutions – advice on choosing equipment to make the most of your fluids

Training can be adapted to your individual needs and delivered on site.

The Q8 family of brands

For the latest up to date technical articles on a full range of products and applications check out the Q8Oils website.

www.Q8Oils.com

www.Q8Oils.com
metal@Q8Oils.com

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