

PETRONAS TECHNICAL STANDARDS
HEALTH, SAFETY AND ENVIRONMENT

DRINKING WATER
(GUIDELINE)

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PREFACE

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AMENDMENTS RECORD SHEET

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TABLE OF CONTENTS

PREFACE	2
AMENDMENTS RECORD SHEET	3
TABLE OF CONTENTS	4
SUMMARY	5
1. INTRODUCTION	6
1.1 Purpose and Scope.....	6
1.2 Legislation and Drinking Water Guidelines.....	7
2. THE BASIS FOR AND USE OF THE GUIDELINES	8
2.1 The Basis for the Guidelines	8
2.2 Use of the Guidelines	8
3. FACTORS INFLUENCING DRINKING WATER QUALITY	9
3.1 Biological Contaminants	9
3.2 Chemical Contaminants	10
3.3 Aesthetic Quality Factors	10
3.4 Radioactive Contaminants.....	10
4. WATER SOURCES.....	11
5. WATER TREATMENT METHODS	12
6. WATER SUPPLY SYSTEMS	13
7. MAINTAINING DRINKING WATER QUALITY	14
8. MANAGEMENT, OPERATION AND MAINTENANCE OF THE SYSTEM.....	15
8.1 Management of the System	15
8.2 Operation	Error! Bookmark not defined.
8.3 Maintenance	16
8.4 Health Surveillance	16
9. TRANSPORT OF DRINKING WATER BY ROAD, TANKER OR SHIP	17
9.1 Source	17
9.2 Tank Material, Disinfection and Construction	17
9.3 Transport of Drinking Water	17
9.4 Storage of Drinking Water	17
10. WATER QUALITY FOR BATHING	18
APPENDIX I WHO RECOMMENDED GUIDELINE VALUES	19
APPENDIX II BIOLOGICAL CONTAMINANTS.....	27
APPENDIX III INORGANIC POTENTIAL HEALTH RISKS	31
APPENDIX IV ORGANIC POTENTIAL HEALTH RISKS.....	35
APPENDIX V AESTHETIC FACTORS USED TO ASSESS QUALITY	38
APPENDIX VI RADIOACTIVE CONTAMINANTS.....	42
APPENDIX VII WATER SOURCES.....	43
APPENDIX VIII WATER TREATMENT METHODS.....	46
APPENDIX IX DESIGN OF WATER SUPPLY SYSTEMS	52
APPENDIX X WATER QUALITY MONITORING	56
APPENDIX XI ANALYSIS OF SAMPLES	62
APPENDIX XII REMEDIAL PROTECTION OF WATER SUPPLIES	64
Table	64
GLOSSARY	66

SUMMARY

This drinking water guide has been prepared for EP operations to provide guidelines for developing and operating potable water treatment plants and related distribution and storage facilities. It includes guidelines for OPU/JVs that obtain their potable water from third parties.

This guideline also recommended maximum allowable levels of living organisms and of relevant organic and inorganic compounds in drinking water intended for human consumption. Specific water quality requirements covering the biological and chemical aspects, their control and maintenance of quality have been described.

These guidelines follow the World Health Organisation (WHO) Guidelines for Drinking Water Quality (Refs. 1 and 2).

1. INTRODUCTION

Water is essential for life. Safe drinking water is vital for a healthy life. Water can contain bacteria, viruses, protozoa, helminths, other free-living organisms and a variety of organic and inorganic compounds. Many of these, if present in sufficient quantities or over prolonged periods, can cause health problems.

1.1 PURPOSE AND SCOPE

It is the objective of these guidelines to recommend maximum acceptable levels of organisms and compounds in drinking water which, if properly implemented, will ensure the safety of drinking water supplies.

The guidelines presented involve recommended maximum levels of living organisms and of relevant organic and inorganic compounds in drinking water intended for human consumption. The recommendations include procedures, methods and systems to assure a healthy quality of potable water from the source to the tap.

These guidelines are produced for PETRONAS OPU/JVs that:

- plan to develop and operate a potable water plant
- operate their own potable water plants and infrastructure
- operate small potable water facilities in the field
- obtain and store their water from third parties, e.g. during field operations such as seismic or drilling, who need to set standards for quality control.

The main body of this document describes the specific water quality requirements. The various appendices provide specific guidance.

For new drinking water plants, the focus will be on control aspects to achieve and protect the drinking water quality. Specific attention has been given to:

- water sources,
- analyses of samples,
- water treatment methods, and
- design of water supply systems and transport of water by truck or boat.

For existing drinking water plants, maintaining water of a good quality is the main focus. Specific guidance can be found on water quality monitoring, using sampling and analytical methods and in case the drinking water quality specification is not met, remedial measures for the protection of water supplies are presented.

1.2 LEGISLATION AND DRINKINGWATER GUIDELINES

National or regional legislation governing standards of water quality may have been set in some areas, in others they may not exist. These will be based on assessments of health risks, water availability and the feasibility of applying treatment technology. There will inevitably be considerable variation in such standards. Where they exist, they must be implemented and enforced. Where they do not exist, or are less stringent than the guideline value specified in this document, the guideline value should be used to define the standard to be applied. The World Health Organisation (WHO) recommended Guideline Values should be adopted for Drinking Water Quality ([Ref.1](#)) for those countries and circumstances where no national or regional drinking water standards exist. The recommended Guideline Values are regarded by WHO as acceptable for life-long consumption.

2. THE BASIS FOR AND USE OF THE GUIDELINES

1.1 THE BASIS FOR THE GUIDELINES

These guidelines follow the World Health Organisation (WHO) recommended Guideline Values for Drinking Water Quality (1993) ([Ref. 1](#)) (see [Appendix I](#)). Each guideline value represents the level (concentration or number) of a drinking water contaminant, which if consumed over a period of a lifetime, would not constitute any significant risk to the health of the consumer, and would ensure aesthetically acceptable water.

The guidelines are based on a per capita daily intake of two litres of water for drinking only, for an average person weighing 60 kg. Obviously, this figure can vary with climate and work load, being as high as ten litres per day in some circumstances. This must be considered when applying the guidelines in specific locations.

Guidelines for contaminants for which a threshold is believed to exist for their toxicity are determined by deriving a tolerable (or acceptable) daily intake (TDI or ADI) from toxicological tests. A proportion of the TDI is allocated to drinking water to allow for exposure from other sources and unless stated otherwise a 60 kg adult drinking 2 litres of water per day is assumed in calculating the guideline values.

Guidelines for constituents that are carcinogens are based on a mathematical model which is used to extrapolate the risk of cancer in animal studies at high doses to the risks at environmental levels of exposure. The value, from the WHO guideline above, is based on a reference risk of one additional cancer per 100,000 population exposed for a lifetime assuming an intake of two litres per day. It must be emphasised that these models are conservative and probably significantly over-estimate the true risks, which may be zero.

1.2 USE OF THE GUIDELINES

The guidelines are intended for use in the development of standards. They are not standards in themselves and may be revised in the light of new information. They describe the minimum quality of water that is currently regarded by the WHO as acceptable for life-long consumption. New standards should be defined using the guidelines and taking into account local environmental, social, and economic factors. If more stringent standards have been set in any location, these should be maintained.

When a guideline value is exceeded, the cause should be investigated, remedial action taken, and the authorities responsible for health notified and consulted for advice. It is possible that short term exposure to chemical constituents at a higher level than that specified in the guidelines, e.g. accidental contamination, may be tolerated. This depends on the toxicity of the substance involved, the amount of the contamination and the period of time the guideline value has been exceeded. Each incident must be assessed individually.

3. FACTORS INFLUENCING DRINKING WATER QUALITY

Substances occurring in drinking water that render it potentially unsafe to drink fall into five main categories. These are:

- biological contaminants
- inorganic compounds adversely affecting health
- organic compounds adversely affecting health
- aesthetically unacceptable components and
- radioactive contaminants.

Poor or ill health resulting from drinking water supplied, particularly in developing countries, is most commonly the result of biological contamination rather than chemical (inorganic or organic) or radioactive contamination.

1.1 BIOLOGICAL CONTAMINANTS

Water extracted for drinking purposes may contain biological organisms, such as bacteria, viruses, parasitic protozoa and helminths, and other free-living, non-pathogenic organisms. Many of these can cause diseases, or they may simply make the water unpalatable to the consumer.

The presence of even a very low number of pathogenic organisms in the water can cause outbreaks of disease within the community, or result in chronic sickness. The main waterborne diseases are:

- diarrhoea of various kinds (viral, bacterial and protozoan)
- typhoid (bacterial)
- dysentery (bacterial or protozoan)
- cholera (bacterial)
- hepatitis A (viral)
- bilharzias or schistosomiasis fluke (trematode) infections
- anaemia caused by hookworm (trematode) infections.

Occasionally, roundworm (nematode) and tapeworm (cestode) infections can be transmitted through drinking water, but these are more usually transmitted either via food or by the direct faeces/oral contact route.

Descriptions of the biological organisms most commonly occurring in drinking water are given in [Appendix II](#).

1.2 CHEMICAL CONTAMINANTS

About 750 chemical contaminants have been identified in drinking water. The health risk resulting from chemical contamination of water differs from that associated with biological contamination. It is unlikely that acute toxicity would arise except in the case of massive (accidental) contamination, and in these instances the water frequently becomes undrinkable because of taste, colour or odour. However, long periods of exposure to low levels of chemicals can result in chronic or cumulative toxic effects. Chemicals can be pharmacologically active, recognised carcinogens or carcinogenic promoters, or mutagenic. Much epidemiological work is still being carried out in this area.

Descriptions of the inorganic contaminants that have been identified as potential health risks are given in [Appendix III](#). The organic contaminants are given in [Appendix IV](#).

1.3 AESTHETIC QUALITY FACTORS

Aesthetic acceptability of drinking water depends on taste, odour, colour, turbidity and hardness. These may not have direct consequences for health, but consumers must find their water acceptable, or they may turn to other sources of supply, possibly of a lower quality. The majority of consumer complaints relate to colour, turbidity, taste and odour. Descriptions of these factors are given in [Appendix V](#). Some of these factors, particularly low pH, can result in 'aggressive' water which leads to leaks and the release of contaminants from piping and other installations, into the water.

1.4 RADIOACTIVE CONTAMINANTS

Drinking water is a relatively minor source of total radiation exposure. Long-lived radionuclides are retained for long periods in the body and the resulting personal exposure may extend over many years. Because of this, radioactivity in drinking water should not only be kept within safe limits, it should be kept as low as is reasonably achievable. The main radioactive contaminants are described in [Appendix VI](#).

1. **WATER SOURCES**

Water for drinking can come from basically three sources. These are:

- groundwater

Either salt, brackish or fresh, obtained via springs or drawn up from wells.

- surface water

Either salt, brackish or fresh, obtained from the sea, lakes, rivers or collected from rainwater (e.g. roof catchments).

The various catchment areas in Malaysia are defined in the Fourth Schedule of the Environment Quality Act, 1974

- bottled / tankered water transported from elsewhere

The source must be capable of supplying the required volume of water ([see Appendix IX](#)). If not, another source or combination of sources must be found.

Groundwater is the preferred source because it is in general not contaminated with pathogenic organisms and requires less treatment to make it safe for consumption. Bottled / tankered water should only be used when other sources are not available or are heavily contaminated requiring extensive treatment.

Purity of source is extremely important, as treatment is expensive, and difficult to implement and maintain to a high level. There is always the risk of failure of the treatment processes, and consequently risk to health. Identification and elimination of sources of contamination, e.g. industrial/domestic/agricultural practices may be necessary.

Factors to be considered in selecting water sources, and their subsequent protection from contamination are given in [Appendix VII](#).

2. **WATER TREATMENT METHODS**

Water treatment aims to render 'raw' water safe for drinking by removing pathogenic organisms, substances which are health hazards, and other constituents affecting the taste, colour or smell of the water.

Groundwater and clear, unpolluted surface water may require only minimal treatment, i.e. disinfection. Turbid and/or polluted water from any source will require more treatment. The processes likely to be necessary to treat both ground and surface water sources, and the aims and effectiveness of the various methods are described in [Appendix VIII](#).

3. **WATER SUPPLY SYSTEMS**

Water must be extracted from an aquifer or drawn from a surface source, transported to the treatment plant, treated and distributed to the consumer.

The major constraints affecting the design of water supply systems are:

- the capacity of the system (quantity of water to be supplied)
- the treatment necessary to render it safe to drink.

The number of consumers and the use for which the water is intended (domestic use, garden irrigation, recreational use such as swimming pools) determine the capacity of the system required. The quality of the selected water source(s) determines the extent of treatment that must be applied to render the water safe for its intended use.

Small community water supply systems should:

- be low cost
- use a minimum of mechanical equipment
- avoid the use of chemicals when possible
- be easy to operate and maintain.

The major criteria affecting system design and materials suitable for use are given in [Appendix IX](#).

4. MAINTAINING DRINKING WATER QUALITY

Drinking water quality monitoring can have two aims, firstly to check that the concentrations of undesirable constituents do not exceed any standards set (no interest is attached to the actual values, provided they are less than the standard values), or secondly to provide reasonably accurate estimates of the various constituents in the water. The second approach is preferred, provided analyses of water samples can consistently achieve the required degree of accuracy. The aim of the monitoring programme should be formulated clearly.

The parameters to be monitored should include:

- biological faecal contamination using coliform bacteria as an indicator
- residual chlorine concentration, to indicate effectiveness of disinfection
- turbidity (colour), taste and odour
- pH
- various chemical and physical constituents.

Quality monitoring comprises both routine sanitary inspections, and the collection and analysis of samples. [Appendix X](#) details the nature of sanitary inspections and the frequency of inspections required, and describes recommended sampling programmes (both frequency of samples and points for sampling).

Analysis techniques for samples collected are described in [Appendix XI](#).

Should any sudden changes in the levels of constituents, or trends in contaminant levels become obvious as a result of the monitoring programme, pollution of the water source may have occurred and remedial actions should be taken. These are described in [Appendix XII](#).

8. MANAGEMENT, OPERATION AND MAINTENANCE OF THE SYSTEM

1.1 MANAGEMENT OF THE SYSTEM

The manager of the water supply system should be a qualified sanitary engineer. He/she is responsible for ensuring that:

- standard procedures are defined and carried out
- records of routine sanitary inspections are kept
- records of breakdowns or failures are kept together with details of remedial actions taken
- complete documentation and drawings exist concerning the design, construction, and layout of the supply system.

In non-routine/emergency situations, the manager should carry out the emergency sanitary inspections and take remedial measures as required.

The manager should liaise with local medical services and government (public health) authorities. Government authorities may be responsible for quality surveillance only of drinking water supplies, or be directly responsible for the provision of water supplies. In some areas they may not be sufficiently staffed and equipped to carry out these functions. The role of government authorities regarding the provision of drinking water and public health should be defined, and lines of communication established.

The number of staff reporting to the manager will depend on the size and type of the distribution system and the extent of treatment applied (if any). These should be suitably qualified technicians trained to collect field data, and inspect and operate the system on a day-to-day basis.

1.2 OPERATION

Good operating procedures should ensure a continuous supply of safe drinking water. Proper workshop facilities, with a sufficient stock of the necessary spares and well trained technical staff are essential in achieving this aim. Routine operations include:

- routine collection of samples for analysis
- routine inspections of the system
- ordering supplies and equipment
- supervising or making water service connections

- reading meters
- answering complaints.

Technical staff should be trained to recognise the indications which precede breakdowns and failures and to keep records.

Non-routine situations require emergency inspections and possibly emergency remedial measures. For such situations, a supply of emergency equipment should be available, including chemicals for disinfection, mobile or portable filter units, pipe accessories, emergency pumps, tools and spare parts. Emergency repair plans should be developed.

1.3 MAINTENANCE

Small community water supply systems should be designed for efficient operation and easy maintenance. The use of standard designs and equipment is recommended. The supply system itself should be as simple as possible, and use only materials specifically designed for the conditions under which they will operate.

The system should be cleaned regularly to ensure that operating efficiency is maintained and that the system itself does not become a source of contamination. Local personnel selected and trained during the construction period can be used to carry out routine maintenance work as they will be familiar with the design of the system.

1.4 HEALTH SURVEILLANCE

Routine medical examinations of drinking water treatment plant operators is ineffective and unnecessary. Examination may, however, be appropriate in the case of these workers reporting sick or in cases of outbreaks of infectious diseases.

9. TRANSPORT OF DRINKING WATER BY ROAD, TANKER OR SHIP

Transport of drinking water by road tanker or ship should be carried out with great care and by trained personnel. The tanks and auxiliary equipment like hoses, valves, etc should be dedicated only for transport of drinking water. The tank should show a clear indication that the water being transported is intended for human consumption.

1.1 SOURCE

The drinking water to be transported to a drinking water storage tank (either onshore or offshore) should comply with the WHO recommended guideline values for drinking water quality described in this document ([Appendix I](#)).

1.2 TANK MATERIAL, DISINFECTION AND CONSTRUCTION

The drinking water transport tank should be made of material not affecting drinking water quality nor promoting bacterial growth. Preferably the tanks are made of stainless steel – ref 1 and 2. Prior to transport of drinking water, and at least once per year, the tank should be disinfected with 100 mg/litre free chlorine for 10 hours, after which the tank is rinsed with drinking water until a free chlorine level of approximately 0.2 to 1.0 mg/litre is achieved. Also hoses and other equipment in contact with drinking water should be disinfected similarly.

The tank should be constructed with a bottom sloping to the delivery point thus enabling complete emptying of the tank after use. It should be possible completely to prevent contamination of the drinking water during and after use.

1.3 Transport of Drinking Water

During transport the residual free chlorine level should be kept at a level between 0.2 and 1.0 mg/litre – WHO guideline (ref 1 and 2). Transport time should be kept as short as reasonably possible to minimise deterioration of drinking water quality during transport. Also increase of the temperature during transport should be prevented as far as it is reasonably possible. After transport a sample should be taken to analyse for the presence of free chlorine, the level of which should not be lower than 0.2 mg/litre. In case the free chlorine level appears to be less than 0.2 mg/litre, free chlorine should be added to the required minimum level of 0.2 mg/litre.

1.4 Storage of Drinking Water

During storage of drinking water the residual free chlorine level should be kept at a level of at least 0.2 mg/litre – ref 1 and 2. Storage time should be kept as short as reasonably possible to minimise deterioration of drinking water quality. The storage tank should be constructed such that ingress of dirt and animals is prevented. Provisions should be made to allow for inspection and cleaning of the tank.

1. WATER QUALITY FOR BATHING

Situations may exist where treated and distributed ground- or surface water intended for human consumption is not meeting all the WHO guidelines for drinking water quality. This water is unfit for consumption, but may be suited for bathing (including showering and washing) and for laundering. Nevertheless, if the distributed water quality is unfit for human consumption it should be treated and distributed with all possible care to prevent misuse that may lead to adverse health effects. Close to each tap it should be indicated, either with a picture or in (an) appropriate language(s), that the water is not fit for drinking, e.g. 'no drinking water'. Starting from the best practical achievable water quality, some of the water parameters listed below are less stringent than those for drinking water intended for human consumption. Water meeting the WHO guidelines for drinking water quality with the exception of the parameters listed below but meeting the values indicated in the table will safeguard human health during bathing and is suitable for laundering.

The parameters indicated below are adapted from the requirements for swimming pools as established by the Dutch Committee for 'water treatment in circulation baths' from the Ministry of Public Health, Physical Planning and Environmental Hygiene, 1981. The adaptations are made to ascertain the health during the use of treated and distributed water for bathing in private bathtubs and showers and for laundering. The requirements listed are not for swimming pools, either private or public. Where the requirements for swimming pool water presented in the above documents are more stringent than for drinking water, they are listed below.

Table 10.1 Quality requirements for water used for bathing and laundering

Constituent or characteristic	Guideline value
Visibility	Clear
Turbidity	5.0 NTU
Taste and odour	Not offensive to most users
pH	6.8 to 8.0
Iron	0.5 mg/litre
Manganese	0.2 mg/litre
Oxidisability (KmnO4)	10 mg/litre
Coliform organisms	None/50 ml/sample *

*It is recommended to maintain or assure a residual-free chlorine level of the bath water at the tap of 0.2 to 0.5 mg/litre

APPENDIX I WHO RECOMMENDED GUIDELINE VALUES

1.1 BACTERIOLOGICAL QUALITY OF DRINKING WATER

Table I.1 Bacteriological quality of drinking water

Organisms	Guideline Value
All water intended for drinking	
<i>E. coli</i> or thermotolerant coliform bacteria ^b	None detected in any 100 ml sample
Treated water entering the distribution system	
<i>E. coli</i> or thermotolerant coliform bacteria ^b	None detected in any 100 ml sample
Total coliform bacteria	None detected in any 100 ml sample
Treated water in the distribution system	
<i>E. coli</i> or thermotolerant coliform bacteria ^b	None detected in any 100 ml sample
Total coliform bacteria	None detected in any 100 ml sample
	For large supplies, where sufficient samples are examined, must not be present in 95per cent of samples taken throughout any 12 month period.

- a Immediate investigative action must be taken either *E. coli* or total coliform bacteria are detected. The minimum action in the case of total coliform bacteria is repeat sampling. If these bacteria are detected in the repeat sample, the cause must be determined by immediate further investigation.
- b Although *E. coli* is the more precise indicator of faecal pollution, the count of thermotolerant coliform bacteria is an acceptable alternative. If necessary, proper confirmatory tests must be carried out. Total coliform bacteria are not acceptable indicators of the sanitary quality of rural water supplies, particularly in tropical areas where many bacteria of no sanitary significance occur in almost all untreated supplies.

Taken from WHO (1993) Guidelines For Drinking Water Quality ([Ref.1](#)).

In the event that the above guideline values are exceeded, then [Appendix VII](#) describes the remedial measures to be taken immediately and the actions recommended to prevent recurrence.

1.1 BIOLOGICAL CONTAMINANTS : OTHER BIOLOGICAL ORGANISM

Table I.2 Biological contaminants: other biological organisms

Organism	Unit	Value	Remarks
Viruses	-	*	Adequate treatment is achieved with: turbidity of <1 NTU; for disinfection with chlorine, pH preferably <8; residual free chlorine levels at least 0.5 mg/litre after 30 minutes (minimum) contact time.
Protozoa	-	*	Remove by coagulation, sedimentation and diatomaceous earth filtration.
Helminths	-	*	Slow sand filtration removes short-lived (48 hours) larvae; for disinfection, residual free chlorine levels 0.5 mg/litre after 60 minutes contact time.
Other free-living organisms	-	**	Disinfect as for viruses and bacteria; ensure equipment/materials do not support growth; flush pipes occasionally; clean with polyurethane foam plugs.

* A guideline value is not practical in these cases as identification and enumeration of these organisms is complex and time consuming. Due to their potential for infection, they should not be present. The most effective way to ensure this is to protect water sources.

** These organisms are too numerous and diverse to set specific guideline values. Their presence is unacceptable to consumers.

NTU = nephelometric turbidity unit

1.2 Inorganic Contaminants Of Health Significance In Drinking Water

Table I.3 Inorganic contaminants of health significance in drinking water

Contaminant	Guideline Value (mg/l-1)	Remarks
Antimony	0.005(P)	
Arsenic	0.01 (P)a	
Barium	0.7	
Boron	0.3	Under review by the EC.
Cadmium	0.003	
Chromium	0.05 (P)	
Copper	2(P)	ATO (under review by WHO).
Cyanide	0.07	