



RP 60-1

COOLING WATER TREATMENT

June 1994

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SCOPE AND PURPOSE This Recommended Practice provides a guide to the treatment of cooling water. Its purpose is to give guidance on the general basis for design and on the quality control of the operating system.											
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Issued by:- Engineering Practices Group, BP International Limited, Research & Engineering Centre Chertsey Road, Sunbury-on-Thames, Middlesex, TW16 7LN, UNITED KINGDOM Tel: +44 1932 76 4067 Fax: +44 1932 76 4077 Telex: 296041											

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FOREWORD

Introduction to BP Group Recommended Practices and Specifications for Engineering

The Introductory Volume contains a series of documents that provide an introduction to the BP Group Recommended Practices and Specifications for Engineering (RPSEs). In particular, the 'General Foreword' sets out the philosophy of the RPSEs. Other documents in the Introductory Volume provide general guidance on using the RPSEs and background information to Engineering Standards in BP. There are also recommendations for specific definitions and requirements.

Value of this Recommended Practice

The reason for producing a BP Group Recommended Practice on Cooling Water Treatment is that there is no widely accepted document adequately covering the issues of interest available in the general literature.

Application

Text in *italics* is Commentary. Commentary provides background information which supports the requirements of the Recommended Practice, and may discuss alternative options. It also gives guidance on the implementation of any 'Specification' or 'Approval' actions; specific actions are indicated by an asterisk (*) preceding a paragraph number.

This document may refer to certain local, national or international regulations but the responsibility to ensure compliance with legislation and any other statutory requirements lies with the user. The user should adapt or supplement this document to ensure compliance for the specific application.

Feedback and Further Information

Users are invited to feed back any comments and to detail experiences in the application of BP RPSE's, to assist in the process of their continuous improvement.

For feedback and further information, please contact Standards Group, BP International or the Custodian. See Quarterly Status List for contacts.



1. INTRODUCTION

1.1 Scope

This BP Group Recommended Practice provides a guide to the treatment of cooling water to render it suitable for use in once-through and recirculating cooling systems. This includes both guidance on the general basis for design and on the quality control of the operating system.

1.2 Application

The application of this Recommended Practice shall take consideration of the particular issues involved in the particular project or application concerned. BP may select options or waive requirements in this Recommended Practice, depending on the nature of the project concerned.

2. QUALITY ASSURANCE

- * Quality system requirements will be specified by the purchaser.

Verification of the vendor's quality system is normally part of the pre-qualification procedure, and is therefore not specified in the core text of this specification. If this is not the case, clauses should be inserted to require the vendor to operate and be prepared to demonstrate the quality system to the purchaser. The quality system should ensure that the technical and QA requirements specified in the enquiry and purchase documents are applied to all materials, equipment and services provided by sub-contractors and to any free issue materials.

Further suggestions may be found in the BP Group RPSEs Introductory Volume.

3. GENERAL

- 3.1 When necessary for a project, the quality of untreated water, its availability and supply conditions must first be established.

Normally, BP will advise a vendor of the above.

- 3.2 As a general principle, cooling water treatment should be provided to permit the use of carbon steel heat transfer surfaces where process conditions allow. There is a need to consider alternative materials for where the water is corrosive and where small bore tubing is in use. A minimum uninterrupted cycle of several years should be guaranteed.

Such use should allow capital cost reduction.



General requirements for pipework can be found in BP Group [GS 142-6](#), of which the piping specifications cover a large proportion of the services within the BP Group requiring various materials.

3.3 To reduce the potential for water side fouling, cooling water should in general be on the tube-side of heat exchangers.

3.4 To maintain heat exchangers and distribution system surfaces in a clean and uncorroded condition, cooling water treatment facilities should be provided to render the cooling water:-

- (a) Non scale-forming.
- (b) Non-fouling.
- (c) Non-corrosive. (See Table 2)
- (d) Hostile to promotion of biological growth.

Such provision will minimise the pumping system power requirements and reduce stoppages for cleaning, maintenance and replacement operations.

3.5 In determining the type and degree of treatment, the following factors shall be considered:-

- (a) The composition of the make-up water.
- (b) The presence of contaminants in the cooling system.
- (c) The residence time of the system.
- (d) The water velocities in the system.
- (e) The maximum water side surface temperature attained.
- (f) The effect of any concentrating mechanism in the system.
- (g) Environmental impact of any treatment regime (see 5.5).

The makeup requirements of open recirculating systems can be minimised by careful selection of treatment regime taking account of the water qualities involved. This will result in the system operating at the most economical concentration ratios.

3.6 For systems associated with air conditioning, treatment shall be designed to prevent development of organisms which, apart from causing fouling, are a risk to health.



Generally a system effectively treated with biocide to prevent physical fouling is a 'safe' system.

The costs of any proposed cooling water treatment system must be evaluated against the benefit to be obtained by meeting the above objectives.

- 3.7 Cooling water systems shall always be segregated from potable water systems.
- 3.8 Cooling systems, in particular closed loop systems associated with air conditioning, shall be designed to minimise the likelihood of legionellosis development. The specific advice of the Health and Safety Executive booklet [HS\(G\)70](#) and the Health and Safety Commission's approved code of practice shall be considered.

4. TYPES OF COOLING WATER SYSTEMS

4.1 General

There are two types of system i.e. once-through and recirculating. These are described below and shown in Figure 1. The relationship between capital and running costs for the alternatives should be evaluated when considering any new cooling water requirement.

The determination of cooling water treatment for a particular system must take into account the particular requirements of each system being considered and in particular the economics associated with the treatment process. The relationship between capital and running costs for the alternatives should be evaluated when considering any new cooling water requirement. Large once through systems cannot cost effectively be treated by chemical additives and thus tend to be constructed of relatively expensive corrosion resistant materials.

4.2 Once-Through Systems

In such a system water passes through the heat exchange equipment only once and is then discharged to waste or to some other process location. Frequently such a system uses large quantities of water and because evaporation is negligible the dissolved mineral salt concentrations do not increase significantly and so the scale problems are slight. Because such large quantities of water are involved the fouling problems can be substantial. The associated temperature increase in passing through the process may render the water more corrosive or liable to form scale. These systems are the simplest and are used where there are abundant sources of water, however, they use and contaminate large volumes of water which are difficult to treat effectively and economically.

4.2.1 Treatment

Treatment is generally dictated by make-up water quality and environmental requirements for the subsequent discharge. Once-through systems are generally employed where:-

- (a) *Make-up water is plentiful and cheap (e.g. large rivers, seawater).*
- (b) *Cooling water is required at a temperature lower than can be achieved using a recirculating system.*
- (c) *Space considerations preclude the use of cooling towers (e.g. offshore applications).*

4.2.1.1 Depending upon the quality of the available make-up or source water, treatment may comprise:-

- (a) Coarse straining.
- (b) Filtration (rarely necessary).
- (c) Addition of conditioning chemicals - e.g. corrosion inhibitor or dispersant scale suppressant. Using corrosion resistant metals such as copper alloys, stainless steel or titanium in the heat exchangers may prove a more cost effective solution in the long term.
- (d) Addition of biocide to prevent biological fouling. Chlorine, whether applied as gas or as hypochlorite, is generally the most cost effective biocide for once through systems.

4.2.1.2 All chemical additives shall be selected to provide the most cost effective technical solution; once-through systems often discharge into open waterways where the persistence of these chemicals may have an adverse effect on the ecology local to the outfall.

Precise chemical requirements cannot be defined without knowledge of the particular application.

4.2.1.3 For seawater systems, protection against 'macro' fouling of intake screens and pumps by shellfish and other macrofauna should be provided. A copper or aluminium based electrolytic anti-fouling system typically located at the pump intakes should be used where appropriate. For complete protection of the main cooling system and control of slime formation, chlorination treatment is also necessary.

Single cell organisms which give rise to slimes are not controlled by a copper aluminium electrolytic system. Control of such species requires chlorination. If chlorine dosing can be practicably introduced into the suction of the water winning

pumps (avoiding generation of high local or transient chlorine concentrations e.g. when pumps are shut down) provision of a copper/aluminium system is not necessary.

4.2.2 Cathodic Protection

When corrosion inhibitors are not used (e.g. in large systems) cathodic protection should be considered for appropriate locations in the cooling system. For shell and tube heat exchangers, application shall comply with BP Group [GS 126-1](#).

4.2.3 Monitoring

Provision shall be made for on-line insertion and removal of specimen material corrosion coupons. These shall be located in the outlet pipework of the hottest heat exchanger unit or system. The insertion point shall be such that electronic corrosion probes can be substituted for specimen coupons if necessary. (See arrangement detail Figure 2).

Corrosion coupons shall be removed typically every 1-3 months for weight loss determinations. This is normally included as part of the chemical supplier service agreement. Table 1 gives a typical monitoring schedule. General guidelines for assessing system corrosion are given in Table 2.

4.2.4 Sampling

Connections shall be provided for taking routine samples for laboratory analysis. Typically, daily samples should be taken to confirm and control adequate chemical dosing levels.

To aid diagnostic studies in the event of plant changes and problems it is recommended that monthly summaries of laboratory data are kept together with inspection reports of any cooling water side examination of heat exchanger equipment.

4.3 Recirculating Systems

There are two types of recirculating systems, one of which is the closed recirculation system, which is where the cooling water/fluid is completely confined within the system pipes. The closed recirculation system is rarely used in the oil and chemical industry, except for chilled- water systems. The other type of recirculating system is the open recirculating cooling water system. In this system water is continuously reused but is open to the air in a cooling tower. As a result, makeup water must be added continuously to replace the water being evaporated from the tower.

For recirculating fresh water systems it is generally more economical to operate, so long as process side conditions allow, with carbon steel heat exchanger equipment and water treatment. The economics are

very dependent upon the degree of concentration which can be achieved (see 4.3.1.1).

When considering water treatment to an existing untreated system the following issues amongst others should be reviewed:-

- (a) *Will the proposed treatment allow the replacement of existing non ferrous equipment with carbon steel equivalents at the end of their service life?*
- (b) *Is there any maintenance activity which can be reduced or discontinued with the proposed water treatment e.g. application of coatings etc?*
- (c) *Are there conservation measures available which will affect the cost of treatment?*

4.3.1 Open Recirculating Systems

For economic operation, open recirculating cooling water systems should be dedicated to cooling use via heat exchanger surfaces. Any use for direct cooling or process water should be avoided. The prime objective is to minimise make-up water demand and chemical consumption commensurate with the requirements of 3.2, 3.3 and 3.4.

Heat rejection is generally attained using cooling tower and spray pond systems. Heat is transferred from the process to the continually recirculating water and by evaporation in the tower or pond to the atmosphere. Note each cycle brings the water into contact with the atmosphere leading to it becoming aerated. Evaporation leads to a concentration of the salts in the cooling water which coupled with the aeration process gives rise to many of the problems associated with recirculating systems such as deposits, corrosion and microbiological organisms. This concentration mechanism is offset by deliberate 'blow down' of water (and other random losses) and addition of make up water.

4.3.1.1 Treatment

The concentrating effect of these systems allows the economical application of chemical treatment but can also give rise to increased potential for scaling, corrosion or both. Each system has an optimum concentration ratio determined by the water composition and consistent with minimum water loss from the system. Decreasing concentration ratio leads to an asymptotic increase in treatment costs (chemicals and make up water). For this reason the use of cooling water for other process water requirements should be avoided.

The quality, cost and availability of make up water determine any pre-treatment necessary.

The primary objective of cooling-water treatment is to protect the exchanger tubing where all the heat extraction takes place. The secondary treatment target is the distribution lines followed by the remaining system components.

4.3.1.1.1 Typical make-up water treatment may involve:-



- (a) Suspended solids removal (straining at point of abstraction, possible filtration).
- (b) Composition modification (e.g. partial softening, alkalinity reduction).

Note that towns water usually has very low suspended solids levels, and therefore does not require a suspended solids removal stage.

The need for and method of make up water softening should be determined in the light of make up water composition, availability and cost. For example an ion exchange de-alkalisation plant may be justified when:-

- (a) *make up water is high alkalinity towns water.*
- (b) *such treatment would allow the system to be run at high (>5) concentration ratio. Such a system should be compared with the use of sulphuric acid for alkalinity reduction. NOTE: This treatment would increase the cooling water sulphate level and could require operation at relatively low (<3) and uneconomic concentration ratios.*

Some waters are naturally soft and acidic and may require addition of caustic to avoid corrosion in the cooling system. Calcium hydroxide is generally the more effective additive but excess dosage can lead to scaling problems. The use of caustic soda can lead to localised ferric hydroxide formation with consequent fouling risk.

- 4.3.1.1.2 The design of any water treatment plant associated with site steam raising facilities should consider the possible requirement for provision of 'part-treated' water for cooling system make-up.
- 4.3.1.1.3 Whenever acid is used directly for make-up water alkalinity reduction, acid addition shall be automatic and pH controlled. Indicators, preferably with chart recorders and alarms, shall be provided to monitor pH in such systems.
- 4.3.1.1.4 For new recirculating water systems, provision for side-stream filtration (e.g. valved branches for possible future addition of filters) should be made whenever any of the following conditions apply:-
 - (a) The local atmosphere is contaminated with particulates.
 - (b) The make-up water is unfiltered and contains more than about 20 mg/litre suspended solids.
 - (c) The anticipated design system concentration ratio will be greater than 3 1/2.

- (d) The system is particularly sensitive to the presence of suspended matter e.g. shell-side cooling, fine clearances in plate-type heat exchangers.

Typically, approximately 2% of the circulating water would be pumped via the side stream filter system to help suspended solids control.

Typically, side stream filter backwash arrangements can be made in conjunction with normal system blowdown pipework requirements.

- 4.3.1.1.5 At locations where water is particularly scarce or expensive, or where there are stringent restrictions on blowdown discharge, provision of side stream softening should be considered.

The softened water product should be returned to the cooling water circuit. Proportion of water diverted to this stage will depend upon circulating water composition and is typically 1-5%.

Only hardness (calcium and magnesium ions) will be removed and some blow down will still be required to control the build up of anions (primarily chloride and sulphate).

- 4.3.1.2 Chemical Additions

Chemical additions comprise corrosion inhibitors, scale inhibitors, dispersants and biocides etc. primarily to control deposition, biological fouling and corrosion.

- 4.3.1.2.1 Despite capital savings, dosing from a single unit to a common make-up supplying several different tower systems should be avoided because of the difficulty in controlling the individual cooling systems at optimum treatment levels. Individual cooling system dosing sets should be used, which may however be supplied from common bulk chemical storage facilities.

- 4.3.1.2.2 Chlorine is generally the preferred additive to prevent biological fouling. A continuous dosing of chlorine with monitoring is the optimal arrangement although small systems may be treated by regular additions of sodium hypochlorite solution. Larger systems do require a more sophisticated arrangement. Electro-chlorination should be considered where supply of bulk chlorine or hypochlorite is not feasible.

The use of liquid chlorine is common practice particularly on large systems. Potential hazards and concerns during transport, storage and coupling operations such as handling, secure storage, potential risk, addition to site emergency plans and training of staff must be considered when selecting equipment. Electrolytic generation of chlorine from sea water or prepared brines will offer a potentially safer alternative but capital costs are generally higher.

The effectiveness of chlorine will decline at higher pHs. Above pH 8 the hypochlorite ion dominates rather than the desired hypochlorous acid. Chlorine will also act as an oxidant to other species present in the system e.g. oils.



Alternative non-oxidising biocides are available as proprietary materials from a variety of chemical service companies. They will be more expensive than chlorine but can allow operation under conditions where chlorine will be ineffective. Their use requires a case by case evaluation. For effective control in a chlorine based system occasional (4-10 times per year) slug doses of proprietary biocide should be made anyway.

Chlorine can be ineffective at penetrating certain forms of slime. The use of a dispersant chemical can help to alleviate this problem.

Cooling and make up water should be sampled daily for laboratory analysis to establish and control additive levels and concentration ratios. Monthly summaries should be kept along with inspection reports of any cooling water side heat exchanger equipment.

Overdose of chlorine can attack wood structures and, if greatly in excess, corrosion of metal surfaces will follow. Therefore close control of chlorine dosing should be employed and where chlorine demand is high supplemented with a non-oxidising biocide.

4.3.1.3 Monitoring

Provision shall be made for on-line insertion and removal of specimen material corrosion coupons. These shall be located in the outlet pipework of the hottest heat exchanger unit or system. The insertion point shall be such that electronic corrosion probes can be substituted for specimen coupons if necessary. In addition, a coupon rack should be provided which will allow simultaneous exposure of several coupons or probes. (See Figure 3 for typical arrangement).

A typical rack location might be immediately adjacent to the cooling tower basin connected to the hot return line or in locations similar to those for heat exchanger probes. Addition of an in line heater could be used to simulate arduous duty.

Corrosion coupons and probes should be removed for inspection and/or weight loss determination every 1-3 months.

4.3.2 Closed Recirculating Systems

Make-up water may be taken from any source. It is preferred, however, that the source should be steam condensate, demineralised water or base-exchange softened water. The use of hard water should be avoided for systems that require frequent topping-up, as the economics of adding chemicals vs. water treatment tend to be unfavourable.

In such systems the water is not exposed to atmosphere and hence there is very little evaporation. Heat exchange takes place through a secondary heat exchanger or intercooler. Closed systems are used extensively for engine cooling, compressors, chilled water systems and tempered water systems. Their main advantage is that critical heat exchange surfaces can be kept in good condition with the minimum of attention.

4.3.2.1 Treatment

Facilities for simple slug dosing of corrosion inhibitors (and anti-freeze where appropriate) to the make-up reservoir shall be provided. Occasional slug dose of biocide may also be required. Simple hand dosing facilities with safe chemical storage should be considered rather than sophisticated facilities.

Both corrosion inhibitor and biocide doses can be very cost effective at levels of several hundreds of mg/l.

Frost protection can be achieved using anti-freeze at an economic level. Compatibility of this chemical with others in use must be considered.

4.3.2.2 Monitoring

A single representative sample point to allow weekly laboratory analysis of the circulating water should be provided where practicable.

On-line monitoring is not generally required. Regular maintenance checks of adequate corrosion inhibitor levels is the prime requirement.

5. DOSING FACILITIES (ALL SYSTEMS)

5.1 Local bulk chemical storage tanks should be sized on the basis of:-

- (a) Chemical consumption rates.
- (b) Chemical availability, economical load size and delivery frequency.

Consideration shall be given to provision of containing bunds or other means of spill containment. This is particularly the case if the chemicals concerned are corrosive (e.g. acid) or toxic (e.g. biocides).

It is recommended that semi-bulk tanks and pumped systems are used wherever possible.

5.2 Chemical dosing pumps shall be provided with simple on-line delivery rate adjustment.

5.3 Safety showers of an approved pattern with eyewash facilities shall be readily accessible from, or specifically provided at, each chemical dosing preparation area.

5.4 Where chlorine is dosed from a liquid gas unit, additional strict safety procedures shall be established. Automatic leak detectors and alarms

shall be provided where there is a risk of leakage of chlorine gas (e.g. storage room and/or gas supply pipework to chlorinator). Emergency self-contained breathing apparatus shall be readily available.

- 5.5 Note that many dosing chemicals used are toxic. The effect of residual amounts of these materials in the cooling water, when discharged into receiving water systems, shall be fully considered. Note also that local or national environmental legislation may prevent the use of otherwise appropriate materials.

Furthermore, many of the dosing chemicals contain components which may significantly affect site effluent discharge permits if spills occur. Adequate facilities for containment of spills shall be provided.

- 5.6 Emergency corrective procedures shall be established for application whenever there is a possibility of significant acid or alkaline contamination and may involve addition of neutralising chemicals.

6. PRE-SERVICE CLEANING

6.1 General

All new cooling systems should undergo pre-service cleaning, to remove construction debris, grease, oxidation products etc. and prepare the surfaces for efficient protection by any corrosion inhibitors to be used in service.

The cleaning programme to be used should depend upon the economics dictated by the system size, complexity and construction materials. Typical stages are:-

- (a) flushing
- (b) chemical cleaning and passivation.

6.2 Flushing

To remove loose debris, the system should first be flushed. The flushing rate should be greater than the service flow rates where possible. Temporary drain points should be fitted where necessary. Small bore pipework (e.g. supply to pump harnesses) is particularly vulnerable to blockage during system flushing. Such sensitive pipework should therefore be disconnected or valved off, and treated separately.



6.3 Chemical Cleaning and Passivation

Generally a specific degreasing stage is not necessary. This will depend upon the condition of the system after construction. When required it will be applied between the flushing and acidification steps.

- 6.3.1 Inhibited acids may be used, being the most efficient cleaning agents for carbon steel systems. Specialist contractors should be engaged for any large-scale acid cleaning operation.
- 6.3.2 Detailed planning is essential to ensure that proper post-acid flushing, neutralisation and passivation is carried out. Special attention shall be given to disposal of spent materials as well as general safety aspects.
- 6.3.3 The final passivation stage will usually involve addition of the normal service corrosion inhibitor (at high dose rate). The supplier of the cooling water treatment chemicals should, therefore, be involved in the pre-clean operation.
- 6.3.4 Specific equipment may require isolation from the cleaning exercise (e.g. stainless steel plant, when using hydrochloric acid) and should be considered at the planning stage.
- 6.3.5 An alternative process to the use of inhibited acids involves employment of proprietary formulations (usually by and under the direction of the cooling water treatment chemicals supplier). This method may be used as it is less complicated, but it is not so efficient. These materials are typically dispersant and surfactant blends which can lift off light corrosion debris and prepare the exposed metallic surfaces for passivation. This operation is commonly carried out at depressed pH levels (approx. 5.0).

6.4 In-Service Passivation and Cleaning

- 6.4.1 Appropriate passivation is also required every time equipment is taken off-line. This is particularly important in cases where zinc phosphate dosing systems, rather than chromate ones, are used.
- 6.4.2 Cleaning regimes employed in service can generally follow as Section 6.3 above. Consideration shall be given to hazards associated with clean out of corrosion debris plugging pinholes.

7. CHEMICAL ADDITIVE SUPPLIERS

- 7.1 Most companies will offer blends of similar treatment chemicals for a given duty. Cooling water treatment chemicals are almost invariably



purchased with a service agreement. The choice of a specialist supply company should depend, apart from cost consideration, on:-

- (a) The support services and back-up provided by the company.
- (b) The ability and quality of service provided by its local representative.

Considerable caution should be exercised in assessing treatment proposals not based upon an independent site survey.

Established suppliers are generally willing to discuss the generic composition and function of the materials offered. This is essential to allow a proper evaluation to be carried out. Reliance should not be placed upon sketchy descriptions and code numbers.

8. CONTAMINATION OF COOLING SYSTEMS

8.1 General

Although correct treatment can maintain a cooling water circuit in a clean non-corroded condition, cooling towers can often become fouled at those zones not directly in contact with the dosed cooling water. Regular inspection of cooling tower internals is recommended. Inspection of 'above packing' zones is often possible although strict safety procedures must be developed.

Most heat exchanger surfaces are designed to allow for some fouling. Others are sized for a maximum process design product throughput. When process-side temperatures are critical, control is sometimes achieved by adjusting the cooling water flow; this can lead to deposition under low flow conditions. Under such circumstances dispersants should be used.

When cooling water has to be on the shell side there is almost always some deposition of water borne debris and consequent risk of under deposit corrosion. In such cases the cooling water should always be dosed with a dispersant chemical to maintain fine debris in suspension.

Contamination issues should be considered in detail when weighing up the advantages and disadvantages of recycling process effluents into cooling systems.

8.1.1 Undesirable contaminants may be loosely classified as:-

- (a) Reducing agents.

Hydrogen sulphide and sulphur dioxide are the most commonly encountered reducing agents in process streams. Such chemicals prevent the formation of, or destroy, protective oxide films and directly react with some corrosion inhibitors. Sulphur dioxide will lower the pH of the cooling water as it is hydrolysed to sulphurous acid. Leaks therefore should be stopped as soon as practicable. High blowdown rates coupled with the use of dispersants should be used during the period of contamination.

(b) Inorganic corrosive agents.

Such materials can lead to both fouling and corrosion problems. Provision should be made for emergency addition of a neutralising chemical when the possibility of contamination is significant. In the event of severe contamination the first reaction should be to increase blowdown as far as practicable and then add the neutralising chemical in a controlled manner. Dispersant chemical should also be added during the upset.

(c) Hydrocarbons.

These usually originate from heat exchanger equipment failure resulting in leakage of process-side materials into the cooling water causing fouling of heat transfer surfaces and often under deposit corrosion. With tightening environmental legislation the possibility of recycle of water streams can also lead to organic contaminants being present in make-up water.

Many hydrocarbons (or other organic chemicals) can act as nutrients for certain bacteria, resulting in enhanced levels of biological activity which, if not controlled adequately by biocides, can give rise to additional fouling and corrosion problems. Such issues must be addressed to identify the most cost effective make-up water source where recycle of process effluents may be considered.

8.1.2 Open systems may be contaminated by airborne particulates or gases from nearby processes. Any chemical treatment programme should consider such effects. Procedures for countering the effects of abnormal contamination should be available to minimise adverse effects.

Commonly encountered issues include:-

- (a) *exhausts from ventilation fans,*
- (b) *proximity of bursting discs which may release dry particulates,*
- (c) *carbon dioxide and sulphur dioxide absorption from entrained flue gases.*

Whilst these will normally be considered in the process design considerations for the cooling system they should also be taken into consideration when specifying the water treatment chemical package.

TEST	SAMPLE POINT	FREQUENCY	TEST BY	REMARKS
pH	Recirculation return or outlet of 'Once Through'	Once per shift or once per day if pH indicator is installed	Works laboratory	Vital if acid addition is used
Inhibitor concentration	Recirculation return or outlet of 'Once Through'	Once per day	Works laboratory	Also checked by inhibitor supplier on service visits
Inhibitor concentration	Closed system	Once per week	Works laboratory	Also checked by inhibitor supplier on service visits
Anti scale or scale dispersant	Recirculation return or outlet of 'Once Through'	Once per day	Works laboratory	Also checked by inhibitor supplier on service visits
Biological activity	Various points in the system	Once per quarter - minimum	Chemical supplier	This will determine if any additional biocide is required
Corrosion readings (electronic)	Various points in the system, especially hot areas	Once per fortnight	Works laboratory	Also at service visit by chemical supplier.
Corrosion readings (coupons)	Various points in the system, especially hot areas	Once per fortnight - examination. Three monthly weight loss determination	Chemical supplier	Corrosion coupons located at hot spots in cooling system.
Total hardness Calcium hardness Alkalinity Chloride Sulphate Silica Suspended solids pH Conductivity Gravimetric tds	Make up and circulating water	Once per month	Works laboratory	Open recirculating and once through systems only
Biological activity	Make up	Once per quarter	Chemical supplier	

TABLE 1
COOLING WATER MONITORING SCHEDULE



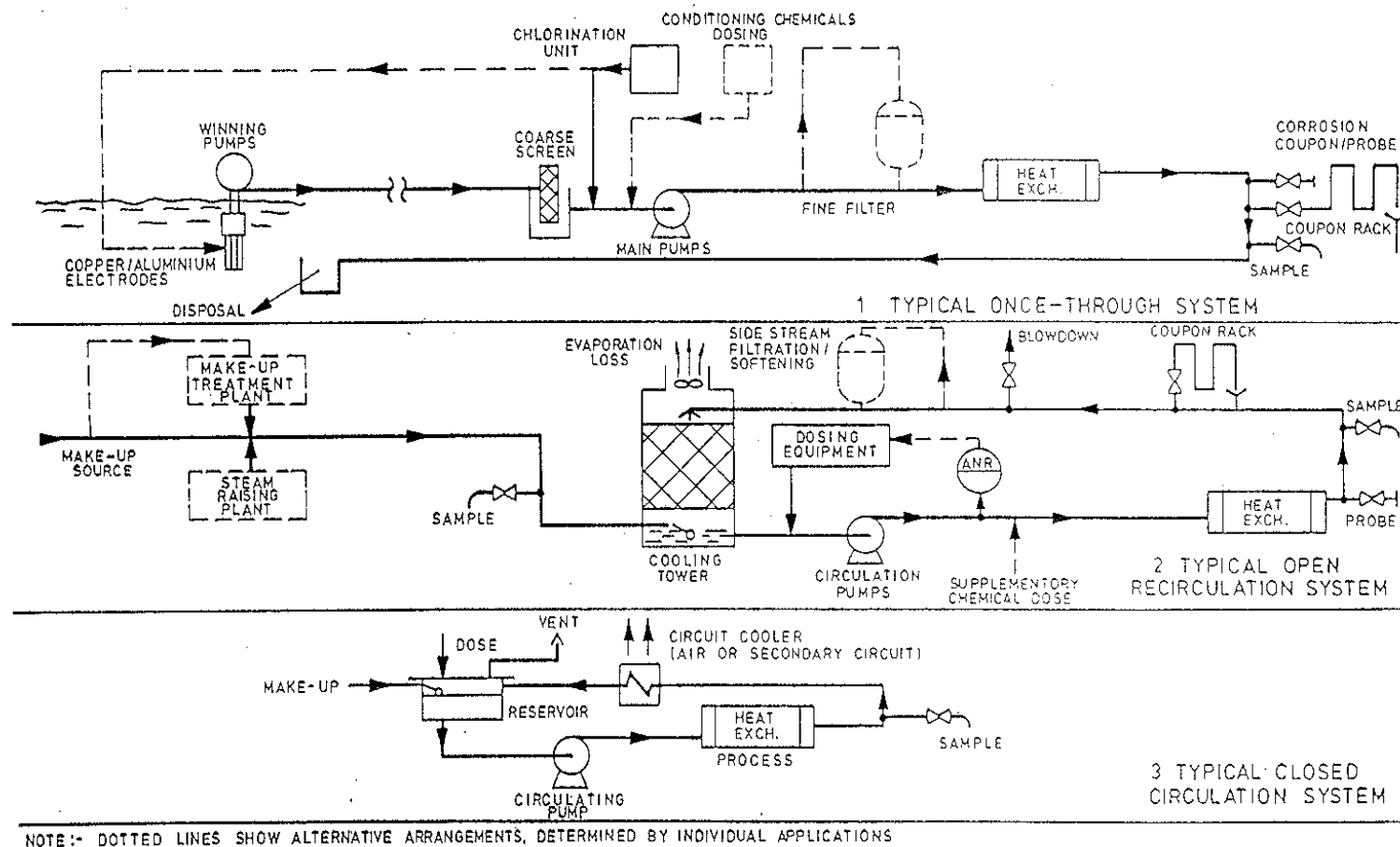
METAL	CORROSION RATE mm/yr	COMMENT
Carbon Steel	0-2 2-3 3-5 5-10	Excellent corrosion resistance Generally acceptable for all systems Fair corrosion resistance; acceptable with iron fouling control programme Unacceptable corrosion resistance; migratory corrosion products may cause severe iron fouling
Admiralty Brass	0-0.2 0.2-0.5 >0.5	Generally safe for heat-exchanger tubing and mild-steel equipment High corrosion rate may enhance corrosion of mild steel Unacceptably high rate for long term; significantly affects mild steel corrosion
Stainless Steel	0-1 >1	Acceptable Unacceptable corrosion resistance

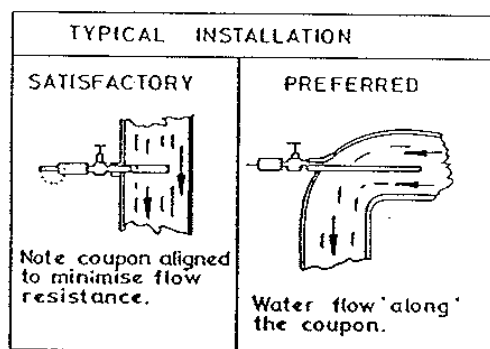
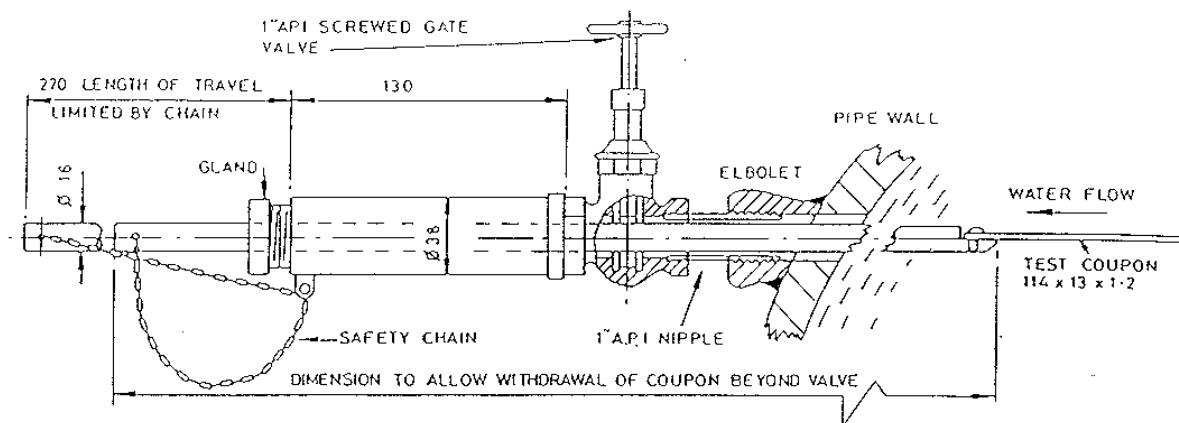
TABLE 2
GUIDELINES FOR ASSESSING CORROSION
(rates apply to general system corrosion)



COOLING SYSTEM TYPES

FIGURE 1





ALL FITTINGS TO BE IN ACCORDANCE WITH BP STD. 170 APPROPRIATE TO THE MAIN COOLING WATER PIPEWORK

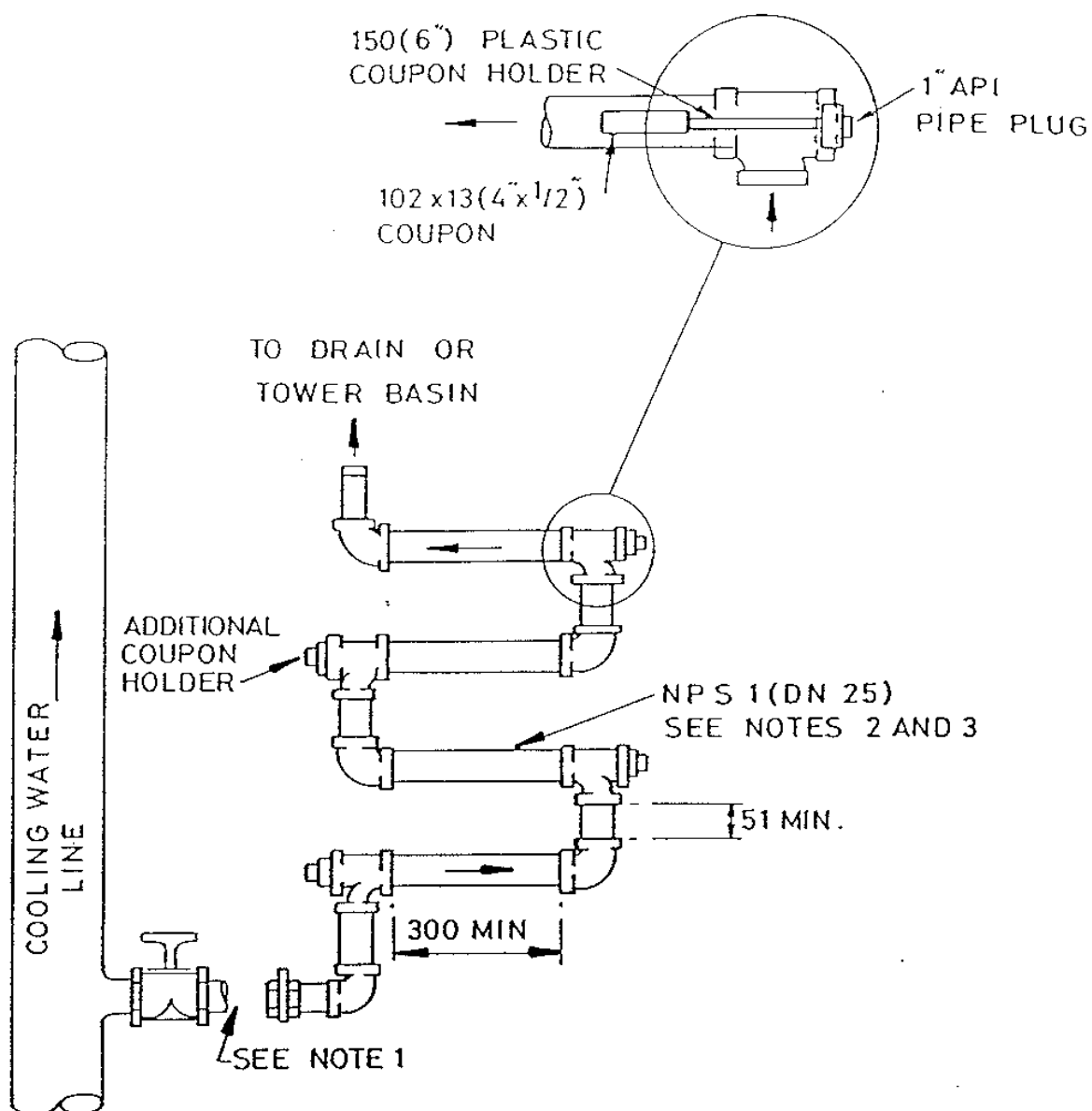
FIGURE 2

WITHDRAWABLE

TYPE

CORROSION

TESTER



NOTES:

1. IN LINE HEATER (WITH WATER OUTLET TEMPERATURE MONITOR) MAY BE INSERTED HERE.
2. PIPE AND FITTINGS SHALL BE IN ACCORDANCE WITH BP STD. 170.
3. RACK SHALL BE APPROPRIATELY SUPPORTED.

FIGURE 3

ASTM (D2688) PATTERN CORROSION COUPON HOLDER

DEFINITIONS AND ABBREVIATIONS

Definitions

Standardised definitions may be found in the BP Group RPSEs Introductory Volume.

Abbreviations

ASTM	American Society for the Testing of Materials
pH	A scale indicating the acidity of a solution



LIST OF REFERENCED DOCUMENTS

A reference invokes the latest published issue or amendment unless stated otherwise.

Referenced standards may be replaced by equivalent standards that are internationally or otherwise recognised provided that it can be shown to the satisfaction of the purchaser's professional engineer that they meet or exceed the requirements of the referenced standards.

BP Group [GS 126-1](#) Shell and Tube Heat Exchangers

BP Group [GS 142-6](#) Piping Specifications

[HSE Guidance Note \(UK\)](#)

[HS \(G\) 70:](#) The Control of Legionellosis Including Legionnaire's Disease

[Health and Safety Commission Approved Code of Practice \(UK\):](#)

The Prevention or Control of Legionellosis (including Legionnaire's disease).

