ABSTRACT

During the compilation of a manual for the testing of water and wastewater treatment chemicals, it became apparent that the national standards for many of these chemicals are outdated and describe analytical procedures which are in some cases obsolete and extremely time consuming. Further investigation revealed that since 1994, the Department of Health no longer produces certificates of health for these chemicals and that the most recent version of the Water Act does not impose any legislation at all on chemicals used for water treatment.

In this paper a brief overview is given of the commonly used water and wastewater treatment chemicals as well as pipes and other materials that come into contact with water. The current status of standards and certification for these products is discussed. The history of certification, both locally and Internationally is described, explaining how the South African standards came to be in the present situation. It is important that chemicals and materials used in the water and wastewater industry are regulated in order to protect the health and welfare of communities and to protect the environment from chemical pollutants and from the possibility of toxic effects due to accumulation of these products in the environment. National standards for these chemicals should therefore be a priority. The South African water and wastewater industry generally follows international standards in terms of the treatment processes and chemicals used, but no regulation/certification system exists in this country for the control of these products. Funding was recently obtained from the Water Research Commission of South Africa to investigate the present South African standards for water and wastewater treatment chemicals and produce recommendations to serve as a basis for the up-dating and re-issuing of current standards and the creation of new standards, where these do not currently exist. This paper highlights the present crisis in this country in terms of water treatment chemical standards and provides suitable strategies for addressing this problem.

INTRODUCTION

The authors recently completed a manual for the testing of water and wastewater treatment chemicals as part of a Water Research Commission (WRC) project (WRC Project No. K5/1600 2004) and in doing so realised that the national standards for many of these chemicals are outdated or worse still, do not exist at all. Many of the current standards, despite amendments, describe analytical procedures which are obsolete, time consuming and do not take into account advances that have been made in analytical technology. This lack in progress in terms of national standards for water and wastewater treatment chemicals, is not only in conflict with the present international trend to regulate these products more stringently, but it is also in complete contrast to the worldwide move towards international certification. It seems anomalous that as more and more South
African water and wastewater treatment plants become ISO certified, many of the process chemicals which they use, remain unlegislated and unregulated. For example, the polyelectrolyte coagulants that are being used ever more widely in this country are not presently subject to any type of formal legislation in this country, despite the potential for adverse health effects that could arise from the use of these chemicals. This paper describes the current status in South Africa, compares the local situation to the current International status and puts forward proposals as to how to remedy the local problem.

**COMMONLY USED WATER AND WASTEWATER TREATMENT CHEMICALS IN SOUTH AFRICA**

There is a wide variety of chemicals used in the production of potable water and purification and treatment of wastewater and effluent in South Africa. In addition to the chemicals themselves, there are also a number of materials, such as pipes, sealants and other surfaces that come into contact with water and effluent and can leach chemicals into the water. A few of these chemicals and materials are described below.

### Polyelectrolytes

Organic polyelectrolytes are high molecular weight synthetic polymers made up of monomeric units and are used as coagulants and flocculants in water and wastewater treatment to improve the solids-liquids separation. The two most commonly used polyelectrolytes for water and wastewater treatment in South Africa are polyamines and polydimethylallyl ammonium chloride (poly-DADMAC or poly-DMDAAC). Polyamines, also known as epichlorhydrin-dimethylamine (Epi-DMA) are cationic polymers formed by the polymerisation of epichlorhydrin and dimethylamine. Very little has been published regarding the toxicity of Epi-DMA, but a large amount of data is available regarding the toxicity of Epichlorhydrin, which can be acutely toxic. A number of studies has been conducted on it and the LD$_{50}$ in rats has been found to be between 90 and 240 mg/kg. Excess monomer present in Epi-DMA could therefore have serious health implications (Letterman and Pero, 1990).

There is also very little literature available on the toxicity of poly-DADMAC or the DADMAC monomer, although the AWWA limits DADMAC monomer in poly-DADMAC to less than 0.05 mg DADMAC per milligram of polymer (Letterman and Pero, 1990). At present there is no South African legislation regulating the use of these chemicals in water.

### Inorganic Salts

A number of inorganic salts are used in water and wastewater treatment as coagulants and flocculants. These are generally iron or aluminium salts and both aluminium and iron are known to have adverse health effects in high concentrations. There are SANAS standards available, such as SANAS 1241-1978 for aluminium sulphate, which specifies concentration of active ingredient and contaminants, but there are no standards regulating the use of these chemicals in water.

### Precipitation, sequestration, pH control, corrosion, scale control and softening chemicals

Chemicals such as lime (limestone, quicklime and hydrated lime), soda ash, caustic soda and various sequestering chemicals fall into this category. SANAS standards are available for some of these chemicals, such as lime and soda ash, but these are in need of updating. For example the SANAS 459-1955 Standard Specification for Lime for Chemical and Metallurgical Purposes includes out-dated gravimetric methods, which apart from being very time consuming, also ignore recent advances in analytical technology. The
available standards specify quality of the products but impose no regulations in terms of usage.

**Disinfectants and oxidants:**
These chemicals cover a wide variety of products, many disinfectants being suitable for use as oxidants and vice versa. The most commonly used disinfectant and oxidant in water and wastewater treatment is chlorine and this can be used in the gaseous form, in solution as hypochlorite or in solid form, usually as calcium hypochlorite (e.g. HTH). Regulations are in place to control the production of chlorine gas and many of the other disinfectants/oxidants as these are usually hazardous chemicals, and there are Department of Water and Affairs and Forestry (DWAF) standards for chlorine concentrations in potable water and discharge effluents, but there are no regulations specifying the allowable contaminants in disinfectants/oxidants used in water treatment, nor the use of these chemicals for water treatment applications.

**Bentonite**
Bentonite is a clay product employed in water treatment processes as a coagulant aid, especially in low turbidity waters where “weighting” of the floc is required. No human toxicological data was found for this product and there are no local standards governing the use of bentonite in water treatment.

**Activated carbon**
Activated carbon is generally used in the water and wastewater treatment industry for the removal of organic contaminants, particularly taste and odour compounds, toxins, pesticides and herbicides. No toxicological data can be found for activated carbon, but it is a hazardous product to store. Presently no legislation nor standards exist in South Africa to regulate the storage and handling of activated carbon.

**Sealants, pipes and construction materials**
The predominant concerns with products such as sealants, pipe and construction materials is the possibility of leaching of potentially harmful chemicals into the water with which they come into contact. In cases where leaching occurs, the general trend is for the initial concentration to be high, but this is usually followed by a rapid decline in concentration with continued contact with the water. Some of these products have certification from international bodies, but there is no regulatory body in this country controlling the use of these products in the water treatment industry.

**HISTORY OF CERTIFICATION**

**History of Certification in South Africa**
Between 1986 and 1994 the then Department of National Health and Population Development evaluated and approved water treatment chemicals on an ad hoc basis. This procedure was based on whether the chemicals met United States Environmental Protection Agency (USEPA) or other international standards. This approval system was stopped in 1994 due to concerns regarding the possible legal implications that could arise from granting these approvals in the absence of a legally binding registration system.

This left the users in a predicament and many of the larger utilities such as Rand Water and Umgeni Water started evaluating these products internally. Laboratory procedures were implemented in order to test the products more thoroughly and in some cases research projects were conducted in an attempt to develop and refine better testing
procedures. Use has also been made of internal specialists, who evaluate the chemicals based on the internal tests and international certification where this is available, but more often using certification for the precursors used in the manufacture of these chemicals.

In 1998, the present Department of Health (DOH), realising the importance of a legally binding system for the approval of water treatment chemicals made an attempt to set up a registration system for water treatment chemicals under the auspices of the Health Act, Act 63 of 1977. The Health Act does in fact provide the DOH with a mandate to regulate the use of drinking water treatment chemicals and the DOH therefore quite rightly believed that as a matter of policy, they needed to ensure that drinking water remains safe and acceptable for use on a sustainable basis.

As part of this initiative, the DOH consulted all the relevant stakeholders, including the users, manufacturers and suppliers and thereafter hosted a workshop in March 1999 in an attempt to coordinate the needs of the industry. The outcome of this workshop was a report on the workshop (Barnes and Makwela, 1999a) and a document titled “Registration System for Drinking Water Treatment Chemicals” (Barnes and Makwela, 1999b), which included contributions from a number of the stakeholders and participants in the workshop. However, this initiative came to a standstill and up to the present time, no further progress appears to have been made by the DOH. Since then the new Water Act has been implemented and the most concerning fact is that the new Act does not impose any legislation at all on chemicals used for water and wastewater treatment.

More recently the authors were responsible for submitting a project proposal to the WRC to produce a document detailing recommended national standards for water and wastewater treatment chemicals (Project K5/1600). This project was awarded to Umgeni Water, the previous employer of the authors, but the authors remain involved in the project through the WRC Project Steering Committee.

The aims of this project are to:
- Evaluate current South African standards and international standards for water and wastewater treatment chemicals.
- Assess the needs of the industry in terms of national standards for water and wastewater treatment chemicals.
- Produce a report containing recommendations which will serve as the basis for the updating and re-issuing of current standards and for the creation of new standards where these do not currently exist.

It is envisaged that the final report will also detail specifications, test procedures, handling procedures and health and safety issues regarding the various process chemicals.

**History of Certification Internationally**
In 1957 concern regarding the health effects of polyelectrolytes prompted the American Water Works Association (AWWA) to ask the United States Public Health Service (USPHS) about the safety of using these products for water treatment applications. In response to this, a programme was developed by the USPHS to review polyelectrolyte safety and the USPHS continued to administer this programme until 1970, after which the responsibility fell on the USEPA. The outcome of this programme was the compilation of a list of accepted products and many American states used these for regulatory and advisory purposes. The list included a maximum dosage for each accepted product, but the USEPA stated that it did not approve, or in any way control the use of polyelectrolytes, serving only to offer advice in this regard (Letterman and Pero, 1990).
The USEPA based its decisions on the safety of polyelectrolytes using technical information provided by the manufacturers. A copy of guidelines used by the USEPA was available, but the criteria used in determining whether a product could be listed as approved, were not mentioned (Letterman and Pero, 1990). By the end of December 1985 the USEPA listed around 1300 products produced by 134 manufacturers, but it is difficult to determine what polymers the different listed products contain, since the USEPA assured manufacturers of confidentiality (Letterman and Pero, 1990). However, there are certainly a lot less compounds than there are products on the list, the literature indicating that there are probably only 11 or 12 polymers associated with this list (Hanson et al, 1983, Mangravite, 1983, Halverson and Panzer, 1980).

Due to limited resources and other demands, the USEPA found it increasingly difficult to manage this product approval list and in 1984, in an attempt to both deregulate the use of water treatment additives and shift the cost of product approval to the private sector, the USEPA proposed that a voluntary and objective body be established to continue with the programme (Letterman and Pero, 1990, McClelland et al, 1989). A consortium led by The National Sanitation Foundation (NSF) and consisting of the AWWA Research Foundation (AWWARF), the Conference of State Health and Environmental Managers (COSHEM) and the Association of State Drinking Water Administrators (ASDWA) was established and a few years later in 1987 the AWWA joined this group (McClelland et al, 1989).

The NSF now has a number of performance standards for products used in contact with potable water and a large number of other product or material standards are available from other bodies such as the AWWA and the American Society for Testing and Materials (ASTM). In order to develop new standards, the NSF has set up various working and advisory groups, which contain representatives from industry, regulatory agencies, water utilities, other product users and from public interest groups. These working groups have played a major role in developing the Water Treatment Additives Programme (McClelland et al, 1989).

A steering committee is responsible for setting policy, administering grants, the work plan programme and programme co-ordination, while specialised task groups address issues such as standards writing and toxicological and risk assessment. The Additives Programme has produced two standards, one of which deals with direct additives and includes all chemicals used in drinking water treatment and the second which deals with indirect additives, including all materials that come into contact with potable water during its treatment, storage and distribution.

NSF standards 60 and 61 were introduced to protect public health by careful consideration of both the additive product and the contaminants which the product contributes to the water and they are based on the principle that the higher the exposure and the risk of a product or impurity, the more data that is required before granting approval for that substance. The maximum allowable limit (MAL) described in NSF standards 60 and 61 for regulated contaminants is based on the USEPA regulated maximum contaminant level (MCL), with the MAL being equal to 10% of the MCL. Contaminants are classified by four different concentration levels and toxicity testing determines in which level a contaminant is placed. A detailed description of the procedure used in this classification is described by McClelland et al, 1989.

The standards development methodology used by the NSF is consistent with the American National Standards Institute (ANSI) guidelines and in fact, the NSF is considered an
accredited ANSI standard organization and NSF standards are accepted by ANSI without additional appraisal. There are presently more than 150 NSF-listed manufacturers in more than 25 countries worldwide and the NSF encourages enquiries from any organisation with an interest in potable water additives standards or the NSF’s Listing Programme.

In Europe, EUREAUA, which governs the European potable water sector, is largely influenced by the World Health Organisation (WHO) guidelines. The first volume of the newly revised WHO guidelines were published in 1993 and it is clearly stated that the primary aim of these guidelines is the protection of public health. They also state that the guidelines are intended to provide a basis for the development of national standards that, if properly implemented, will ensure the safety of drinking water supplies through the elimination or reduction to a minimum concentration of constituents in water known to be hazardous to health (WHO Short Report, 1994).

A member state of the European Union (EU) is not obliged to adopt the new WHO guidelines into its legislation until such time as these are incorporated into the revised EU drinking water directive. The WHO guidelines are based on the precautionary principle and therefore if national standards vary from the WHO guidelines it does not necessarily mean that health protection is being compromised. The WHO guidelines state that the amount by which and the period for which any guideline value can be exceeded, without affecting public health, depends upon the substance in question (WHO Short Report, 1994).

As far as polyelectrolytes are concerned, the WHO guidelines refer only to epichlorhydrin and acrylamide and state that since these compounds can hardly be detected in water using the normal routine measurements, their presence in water needs to be limited through legislation and standardisation for chemicals and materials which come into contact with drinking water (WHO Short Report, 1994). Certain European countries, like France appear to have taken the initiative in this regard and have established their own legislation regarding the use of polyelectrolytes in drinking water treatment.

INTERNATIONAL REGISTRATION / CERTIFICATION SYSTEMS

In finding a system which is suitable for the South African system it seems logical to refer to other countries and examine the systems that they have implemented. It is of interest that Australia, a country which in terms of climate and environment shares some similarities with South Africa, did still not have any regulatory requirements for the control and use of drinking water treatment chemicals as recently as 2003 (Drew and Frangor, 2003). In 1998 the National Health and Medical Research Council of Australia (NHMRC) endorsed the “Guidelines for Clearance of Water Treatment Chemicals and Processes”, which outlined the data required for drinking water treatment chemicals and provided a standardised approach for the assessment of their safety and efficacy. However, these guidelines did not constitute any regulatory requirements and only a relatively small number of water treatment chemicals were evaluated using these guidelines. Since the mid 1990s Australia has lacked a practical means of assessing and approving water treatment chemicals and as a result is in a similar predicament to South Africa in this regard.

More recently in 2000 the NHMRC established the Drinking Water Treatment Chemicals Working Party in order to initiate a national approach to the assessment and approval of drinking water treatment chemicals. This working party commissioned a report (Drew and Frangor, 2003) which describes and compares the procedures and policies that are employed by Australian and international organisations and regulatory bodies for the evaluation and approval of water treatment chemicals.
The Australians, in devising their regulation system have focused on three well established international evaluation schemes for the evaluation of drinking water chemicals, which are without doubt the most advanced, well-known and comprehensive schemes in existence (Drew and Frangor, 2003). These are:

- the USA-NSF processes
- the procedures of the UK Committee on Products and Processes for Use in Public Water Supply
- the Kiwa-regulations for “Assessment of Toxicological Aspects” from the Netherlands.

Drew and Frangor (2003) summarise these three systems in Table 1 below, in which the main characteristics of the regulatory conditions and general processes and policies of these schemes are compared.

**TABLE 1: Comparison of USA-NSF, UK and KIWA (Netherlands) systems (taken from Drew and Frangor).**

<table>
<thead>
<tr>
<th>USA-NSF</th>
<th>UK</th>
<th>KIWA (Netherlands)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Responsible Body</strong></td>
<td>USEPA</td>
<td>‘Secretary of State for the Environment, Transport and the Regions’ and ‘The National Assembly of Wales’. Theses authorities delegate administration of, and compliance with the regulations to the ‘Drinking Water Inspectorate (DWI).’</td>
</tr>
<tr>
<td><strong>Cost Recovery</strong></td>
<td>100% (i.e. no public money is used in the approval process).</td>
<td>None. The product supplier pays only for generation of data, but not for the costs of approval. The approval process is funded using public monies.</td>
</tr>
<tr>
<td><strong>Approved, Validated &amp; documented protocols</strong></td>
<td>Analytical techniques, toxicological methods and drinking water standards referenced are mainly derived from approved and documented US/Canadian Government protocols.</td>
<td>CPP assessment appears to be done by expert deliberation since specific guidance rules for the risk assessment process do not appear to exist. BS:EN standards mandate certain parameters.</td>
</tr>
<tr>
<td>Compliance Requirements</td>
<td>USA-NSF</td>
<td>UK</td>
</tr>
<tr>
<td>-------------------------</td>
<td>---------</td>
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</tr>
<tr>
<td>USA-NSF</td>
<td>Mandatory in the most of the States in USA, voluntary in some and no requirement in a few States.</td>
<td>Mandatory on water works in the UK.</td>
</tr>
<tr>
<td>Quality Assurance/ control procedures</td>
<td>Initial evaluation includes review of formulation, laboratory analysis and audit of manufacture. Unannounced audits are conducted after approval. Notification to certifying agent required if any changes to process are made.</td>
<td>Compliance audits are conducted on the water works to ensure that products being used are approved or meet relevant BS:EN Standards.</td>
</tr>
<tr>
<td>Toxicology data required</td>
<td>Yes.</td>
<td>Yes – CPP. extent dependent on product impurities and judgement.</td>
</tr>
<tr>
<td>Toxicology data formally assessed</td>
<td>Yes – by toxicology / risk assessors within NSF or contracted to NSF.</td>
<td>Yes – by CPP who are an independent group of experts but are not all toxicologists.</td>
</tr>
<tr>
<td>Certification / accreditation</td>
<td>Certification required in most USA States.</td>
<td>Approval required in UK.</td>
</tr>
<tr>
<td>Aesthetic evaluation</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Treatment by-products considered</td>
<td>Yes</td>
<td>No information</td>
</tr>
<tr>
<td>Efficacy considered</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Public consultation</td>
<td>No public notification / consultation is required. A listing of approved products is publicly available on the Internet.</td>
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</tr>
</tbody>
</table>

All three of these systems base their evaluations and approvals on propriety products rather than on generic chemicals and their health risk assessments focus on the end user, which makes sense as this is where the public health risk, if present, will exist. All three systems provide for regular audits of the manufacturers facilities and quality systems and for periodical random sampling of the chemicals and their precursors.

The USA-NSF, UK and KIWA systems all use two basic processes in technically evaluating the chemicals. The first involves comparison of the chemical constituents, impurities and other by-products of the chemical with the standards for a generic compound, which specifies allowable limits for contaminants. In many cases the standard also specifies analytical procedures that should be employed in characterising the chemical.

The second process involves assessment of the health risk factors posed by the chemical(s) and generally requires both comprehensive chemical analysis of the product as well as toxicological data, although the methods used for risk assessment vary between these three regulatory systems.

The World Health Organisation (WHO) is another regulatory body from which valuable information can be gained in terms of how a South African Regulatory system can be
developed. The 1993 WHO Guidelines, which are discussed in section 3, provided information on only a few of the more important contaminants that arise from the use of water treatment chemicals and construction materials and failed to provide recommendations on how to develop new standards (WHO, 1993). However, more recently WHO has developed a training package (WHO, 2001) designed to assist countries in developing standards and specifications to regulate water treatment chemicals and construction materials and ensure a safe drinking water supply. For water treatment chemicals for which national standards exist, WHO (2001) promotes the dilution equation used by the NSF and the US National Research Council for calculating the Recommended Maximum Impurity Content (RMIC) for the chemical. Where no standards exist, WHO (2001) suggests that toxicity testing may be required in order to establish a “national standards value” from which the RMIC can be determined.

In the case of construction materials used in water works and distribution systems, WHO (2001) takes into account the fact that although the amount of contaminant that is released from a construction material may initially be high, it usually decreases rapidly with continued contact with the water. WHO 2001 describes a parameter called the NOAEL or “no observed adverse effect level” which is determined in a 90 day test which observes the adverse effects of animals consuming water or food during this period and states, “If the initial (day 1) leachate concentration of contaminant is less than or equal to the 90 day NOAEL divided by 100, and the contaminant concentration is calculated to be at or below 10% of the national standard, then no additional toxicity data may be required”. WHO 2001 recommends that the International Organisation for Standardisation (ISO) would be an appropriate international body to co-ordinate the national standards and test procedures relating to extractable toxic contaminates from construction materials used in the potable water industry.

PROPOSED STRATEGIES FOR IMPLEMENTATION OF SOUTH AFRICAN STANDARDS

It is clear that the regulatory and approval systems described in Section 4 above are already highly developed systems and that we in South Africa could adopt the general principals that they employ and even introduce the technical evaluation methods available in these systems instead of embarking on a time consuming and expensive process of pioneering a completely new system. There is a wealth of standard procedures, such as the NSF ANSI methods, the UK BS:EN Standards, the German DIN standards and WHO Guidelines, which can be purchased from the relevant Certifying body, rather than developing completely new methods. In addition, the South African National Accreditation Services (SANAS) has a number of its own methods and although some of these methods have become outdated and do not take into account advances that have been made in analytical technology over the past few decades, there are still many that would be appropriate for inclusion in a national accreditation system for water treatment chemicals and materials which come into contact with water.

Logically responsibility for obtaining certification for products should rest with the manufacturer/supplier and not the user and there are a number of reasons for this:

- The manufacturer is generally better equipped to analyse for restricted substances in the various chemicals than the supplier or user.
- Measurement of restricted compounds will be far easier in the concentrated solution form where they appear in much higher concentrations than in the final treated water.
For most water treatment chemicals and water supply construction materials, there are usually only a limited number of products for each type and a limited number of manufacturers for each product in the country and therefore monitoring and auditing of these few industries will be far easier to manage than monitoring of the large number of users of these products.

In many cases the user is unsophisticated and/or uninformed and therefore unable or not equipped to determine the concentration of potentially harmful contaminants present in the chemicals or materials. In addition to this, the manufacturer knows what compounds have been used in producing the products and it is therefore much more practical that the manufacturer is responsible for ensuring that his product complies with the necessary specifications.

The international regulatory bodies described in Section 4 have considerable experience in the regulation of water treatment chemicals and water supply construction materials and it would therefore appear logical to tap into their knowledge. The DOH then needs to set South African standards for the final product or for the manufacturing process used in order to limit the contaminants in the final product and this must include standard analytical procedures for measurement of potential contaminants. It is clear on observing the successful regulating bodies such as the USA-NSF, UK CPP and KIWA, that this process will only be successful if the DOH establishes an evaluation committee which comprises all the major role players, such as the DWAF, the Department of Environmental Affairs and Tourism, representatives from the various water utilities, manufacturers and any other relevant stakeholders. It will be the duty of this committee to make recommendations based on either the potential health effects of the product(s) on the end user and/or environment, or based on data provided by an accredited laboratory. Furthermore, the committee should have the authority to request additional information where deemed necessary. Toxicological assessment of products will be required, but obviously in cases where registration is sought for a product which is already registered under a recognised international system, it will not be necessary to evaluate the product further.

Based on the standards and regulations implemented, the manufacturer would be able to specify the maximum concentration at which his product can be safely used for its intended purpose. Once a manufacturer has obtained approval for his product(s), he should also be called upon to test individual batches of the product and the results of these analyses recorded in a book of compliance. The Department of Health would have to implement an auditing system to allow for random checking of the manufacturers’ results, with tests being conducted by an independent laboratory.

CONCLUSIONS

There is no doubt that a registration system for water treatment chemicals and construction materials is urgently needed in this country and that adopting the policies and principles of the internationally successful registration bodies will be the most effective way, both in terms of cost and time, to introduce such a system in South Africa. The DOH, which seems to be the logical authorising body in this case, must however ensure that such a system does not restrict smaller manufacturers or prevent new industries from being established. It is therefore critical that implementation of the system and costs are carefully considered, otherwise it could result in unfair competition for smaller businesses.
REFERENCES