A NEW LOOK AT "TEN STATE STANDARDS"

A Report By

Committee to Study Engineering Design Standards

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To

Iowa Water Pollution Control Commission
Robert Buckmaster, Chairman
State Department of Health
State Office Building
Des Moines, Iowa

May 25, 1967

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OF SCIENCE AND TECHNOLOGY
Ames, Iowa

DEPARTMENT OF CIVIL ENGINEERING

April 5, 1967

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Gentlemen:

I want to remind you that we have scheduled a meeting of our Committee to be held in the Purdue Room of the Iowa Memorial Union on Thursday, April 13, 1967 at 10 A.M.

You will find enclosed a xerox copy of a ROUGH DRAFT of the final report for our Committee. I have attempted to take the draft of the various sections on which we have worked and incorporate them into one report which expresses the ideas which we have discussed in our previous meetings. I hope each of you will have had an opportunity to review in detail the contents of this report and to be prepared to tear it apart and put it back together again at our meeting next Thursday.

I have by phone and by means of this letter forwarded one copy of the report to Paul Houser and extended an invitation to Paul and Mr. R.J. Schliekelman to attend this meeting to discuss with us the work we have accomplished on this Committee. This should give us an opportunity to modify any statements made or any unclear thoughts so that the report of the committee will serve to "enhance" rather than hinder the work of the professional staff of the Iowa Water Pollution Control Commission. I will look forward to seeing you next Thursday.

Most sincerely,

Bob

E. Robert Baumann, P.E.
Chairman

ERB:rf

Encls.

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A NEW LOOK AT TEN STATE STANDARDS

I. INTRODUCTION

A. Assignment

In 1965, the Iowa legislature created the IOWA WATER POLLUTION CONTROL COMMISSION and assigned to it full responsibility for water pollution control in Iowa. In order to meet that responsibility, the COMMISSION has adopted surface water quality criteria which are applicable to all surface waters and to specific designated water uses; namely, public water supply, aquatic life, and recreation. The COMMISSION must evaluate the surface waters in the state and establish a standard of quality for each stream or for designated reaches of each stream, and for other surface waters which are in accordance with the recently adopted surface water quality criteria and the uses which are being or will be made of the surface waters. Once stream standards are established for Iowa surface waters, the COMMISSION will have to establish effluent standards for each municipality, industry, or other administration unit discharging waste waters into the surface waters of Iowa. The effluent standard should be established on the basis of the stream standard applicable to the receiving body of water, the characteristics of other current or future discharges affecting the stream water quality, and the treatment technology applicable to these discharges. The effluent standards should indicate the quantity (gallons per day) and quality (concentration of specific pollutants) of the waste waters* which each water user will be permitted to discharge. The effluent standard should also specify the total time period during which the effluent standard shall apply.

The treatment technology standards currently used by the Iowa State Department of Health as engineering design standards were first written and adopted in 1947-48, (the latest edition is dated May 10, 1960) by the Great Lakes-Upper Mississippi River Board of State Sanitary Engineers. These standards are published as "Recommended Standards for Sewage Works" and are applicable in the States of Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, New York, Ohio, Pennsylvania, and Wisconsin. Since they were prepared and approved by and are applicable in these 10 states, the design standards are frequently referred to as the TEN STATE STANDARDS.

In order to evaluate the current applicability and effectiveness of the "Ten State Standards" in light of the new water pollution control objectives to "enhance" water quality, the Iowa Water Pollution Control Commission authorized the appointment of a "COMMITTEE TO STUDY THE ENGINEERING DESIGN STANDARDS CURRENTLY USED -- AND TO ADVISE THE COMMISSION CONCERNING THESE STANDARDS."

On October 27, 1966, the Chairman of the Commission invited the following professional engineers to serve on the COMMITTEE:

1. Dr. E. Robert Baumann, P.E., Professor of Civil Engineering, Iowa State University,
2. Kenneth M. Bright, P.E., Stanley Consultants Inc., Muscatine,
3. Charles D. Mullinex, P.E., Howard R. Green Company, Cedar Rapids, and

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* The standard might specify, for example, either the pounds of BOD per day that could be discharged or could specify the concentration of BOD which could be discharged in a given maximum volume of waste water.

4. Dr. H. Sidwell Smith, P.E., Professor and Head*, Civil Engineering, State University of Iowa.

All accepted the invitation to serve and on November 16, 1966, Dr. E. R. Baumann was asked to serve as Temporary Chairman of the Committee. Initial COMMITTEE assignments were made by correspondence followed by sessions of the full committee. All Committee meetings were held at the Memorial Union of the State University of Iowa in Iowa City. Committee meetings have been held at approximately one-month intervals as follows:

1. December 13, 1966 (10:00 A.M. - 4:00 P.M.)
2. January 10, 1967 (10:00 A.M. - 3:45 P.M.)
3. February 14, 1967 (10:00 A.M. - 3:00 P.M.)
4. March 14, 1967 (10:00 A.M. - 3:00 P.M.)
5. April 13, 1967 (10:00 A.M. - 3:00 P.M.)

All committee members have attended all committee meetings. At the December 13, 1966 meeting, Baumann and Bright were appointed to serve as Chairman and Secretary of the Committee, respectively.

The first four COMMITTEE meetings were used to discuss the "Ten State Standards", their purpose, and the areas where constructive criticisms could be directed. Between meetings, each member of the committee prepared drafts of the COMMITTEE REPORT in specific assigned areas. These were discussed and extensively modified at subsequent meetings. At the March 14, 1967 meeting, the COMMITTEE agreed on the essential points to be made in the final report. The Chairman was assigned the task of preparing a report for the April 13, 1967 meeting. Representatives of the Iowa State Department of

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* Effective July 1, 1967 Dean of Engineering, University of Idaho, Moscow, Idaho

Health concerned with water pollution control attended this meeting and were invited to comment concerning the preliminary draft of this report. The COMMITTEE REPORT was subsequently revised and is presented herein.

B. Evaluation of the Problem

Public demand for improved water pollution control objectives dictates reevaluation of waste treatment methods and procedures compatible with our state water quality criteria. The primary assignment of this advisory committee, therefore, lies within the scope of reevaluation of waste treatment methods and procedures currently recommended by the "Ten State Standards". Any such reevaluation should consider the formulation of parameters with latitude for decision by the designer to utilize fully the best current experiences compatible with the basic and engineering sciences involved in waste treatment. Practically all of the current methods, procedures and operating techniques have been developed by exercising such latitude through knowledgeable application of these basic sciences.

Continued demands for higher treatment efficiencies make it mandatory for further sophistication in methods, procedures and operating techniques to attain our water pollution control objectives. In turn, the development of such sophistication is dependent upon the values of the important parameters with latitude for decision by the designer, including the responsibility for the decision. The "Ten State Standards" were never intended to be "cookbook" standards for design, particularly in an era involving systems analysis and inter-related sociological environmental planning. Since water pollution control objectives have been established by water quality criteria demanding ever-increasing waste treatment efficiencies, it is imperative that such improvement and sophistication be developed. Further, such improvement and sophistication will require imaginative and knowledgeable application of the basic and engineering sciences involved, together with intelligent interpretation and utilization of past experience and performance records.

The TEN STATE STANDARDS were "intended for use as a guide in the design and preparation of plans and specifications for sewage works; to list and suggest limiting values for items upon which an evaluation of such plans and specifications will be made by reviewing authority; and to establish, as far as practicable, uniformity of practice among the several states."(1) In effect, then, the TEN STATE STANDARDS were <u>only</u> intended to serve as a guide in design and to indicate items which the reviewing authority would check in determining the adequacy of the design. It was assumed that all designers would have adequate competence in the basic fundamental principles involved in the design of water pollution control facilities. Accordingly, the major items included in the STANDARDS are concerned with the citing of a number of design parameters (loading rates found effective in practice, for example) and the listing of so-called "<u>hardware standards</u>" (physical features needed to enable the system to function adequately).

In summary, the COMMITTEE believes that the TEN STATE STANDARDS are currently inadequate in the following areas:

1. There is need for a restatement of the PHILOSOPHY behind the very existance of the STANDARDS to redefine their purpose and the responsibilities of the parties concerned.

(1) TEN STATE STANDARDS - Foreword

2. There is need to include in the STANDARDS an understanding of the PRINCIPLES involved in the processes used so that both reviewing authority and designer have a common point from which to evaluate departures from current practice. Text book

3. There is need to update the HARDWARE STANDARDS and design parameters and to facilitate continued updating at more frequent intervals. Done

4. There is need to facilitate and encourage the use of innovations which contribute to economy and efficiency of water pollution control. '56 Lagoons Aerated Anaerobic

C. Approach in this Report

Thus far, the COMMITTEE has only stated what they consider to be the problems involved in the use of the TEN STATE STANDARDS as the engineering design standards in Iowa. Obviously, the best way to express the philosophy and design standards considered to be in the best interests of water pollution control would be to rewrite the TEN STATE STANDARDS in the form the COMMITTEE believes they should assume. Unfortunately, this COMMITTEE is too small, time is too limited, and the applicability of the standards too widespread for us to complete such a task. However, such a task should be undertaken. The Committee which accomplishes the assignment should include representatives, competent in both principles and practice, of water pollution control agencies, equipment manufacturers, consulting engineering firms, education, and of course, representatives of the owners of pollution control plants who will be responsible for their successful operation.

To serve as a guide as to the direction in which the TEN STATE STANDARDS should go, the COMMITTEE has prepared a preliminary draft of several pertinent sections for a REVISED TEN STATE STANDARDS. These drafts are not intended to be final statements; they are designed to serve as approaches that can be taken to solve what are considered to be the problems inherent in the use of the current TEN STATE STANDARDS as engineering design standards.

II. PHILOSOPHY OF REVISED TEN STATES STANDARDS

The following "FOREWORD" has been prepared to represent what this COMMITTEE believes should be the "basis for creation of standards" and "the responsibilities of the various parties concerned with water pollution control". It is recommended that a REVISED TEN STATE STANDARDS include the principles expressed herein as its FOREWORD:

FOREWORD

Standards by which the quality of a product or its performance can be judged are an important part of modern engineering. Their nature varies from precise definition such as our standards of weight and measure to statements of broad concepts based on empirical experience and comprised of a mixture of "performance" criteria and "hardware" requirements. The present "Recommended Standards for Sewage Works" or TEN STATE STANDARDS are of the latter types. Building codes are examples of engineering standards which lie between the two extremes.

The best designs result from the creative use of reliable information (principles, practice) to produce a solution suited to a given situation. The proper role of a standard is as a guideline to competent designers. A standard cannot be a handbook to take the place of competent engineering.

Standards based on empirical experience must have clear reference to the nature and limitations of the experience. They must provide for the impact of both additional experience and new basic knowledge. Failure to use and administer standards accordingly will stifle progress and deny the benefits of the added experience and new knowledge to the eventual user of the product.

Empirical standards, since they are based on experience, are subject to individual interpretation and administration. This affects the relative role that the standards and each of the involved parties plays in the conception-analysis-decision-execution process necessary to effective design. Therefore, statements concerning the responsibilities of the principal parties concerned in water pollution control are an important part of such standards.

In accordance with the foregoing, standards which will afford adequate guidelines as well as help advance the science and art of wastewater treatment and water pollution control should provide the following:

1. A combination scientific and practical viewpoint representing best current experience but with sufficient recognition of the basic mechanisms involved to permit qualified parties to go beyond the limitations of prior experience when dictated by project conditions and/or new knowledge. It is expected that "best current experience" will be sufficiently inclusive to cover all normal situations without requiring retracing of prior development for each such situation. A "normal" situation is one in which the quality of the waste and its manner of discharge to the treatment system is similar to that in other installations to which the standard criteria are known to apply.
2. A forthright declaration of the responsibilities and relationships of those considered to be the principal parties involved in the creation and abatement of a water pollution problem: the Owner, the regulatory agency, and the engineer.

Involved Parties

Owner

The Owner creates the water pollution problem and has the responsibility for taking the corrective steps necessary to abate the problem including the construction and operation of whatever pollution control works are required. The Owner may be a public body such as a municipality or sanitary district or a private corporation such as an industry or residential development.

The Owner, in the last analysis, is responsible for all aspects of the problem and the measures taken for its correction. He may delegate responsibility for certain phases (such as engineering) to others but such delegation does not relieve the Owner of the eventual responsibility for meeting and maintaining the degree of abatement ultimately required by the regulatory agency.

Particular attention is directed to the Owner's responsibility to provide continuous operation of its treatment facility with that competency required to produce results meeting regulatory requirements up to the capability of the installed treatment system. The Owner also has the responsibility of anticipating demands on the treatment system in excess of its capability and of initiating steps toward enlarging treatment capacity sufficiently in advance of need to prevent discharging effluent of lesser quality than that required by the regulatory agency.

Regulatory Agency

The regulatory agency is concerned with investigation and enforcement related to maintenance of established stream standards. It is further concerned with the establishment of waste discharge qualities to be met by various water users (Owners), review and approval of the Owner's proposals and plans for achieving the waste discharge quality established and surveillance of operations of installed waste abatement facilities. The regulatory body may be a local, state, or federal agency. Most often it is an engineering division of a state department of public health.

The regulatory agency's position with respect to proposed abatement measures should be limited to review of the Owner's proposals and plans within the guidelines provided by the standards. The Owner and Engineer should select the methods to be used to satisfy the specific waste quality criteria established by the regulatory agency. Eng Qualified

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Engineer

The engineer is the professional person charged with the responsibility of defining the problem, conceiving alternative solutions and selecting the solution best suited to the particular case, developing detailed plans and specifications for the physical facilities involved and super-

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vising the construction of these engineering facilities. The engineer should also participate in the early operation of the project to assure that the intended performance is actually obtained. The engineer may be an agency within the Owner's organization, an outside agency engaged for a particular assignment, or a combination of both. The engineer provides only professional services and does not directly engage in any way in the construction or equipping of public engineering works.

The engineer is responsible for understanding objective criteria imposed by the regulatory agency, conceiving feasible alternates within the standard guidelines for meeting these criteria, evaluating all such alternates and recommending the most feasible plan to the Owner and regulatory agency. The engineer is expected to provide a rational defense of his recommendations. After agreement on the recommended plan the engineer produces the final designs and drawings for required engineering works. These plans, to be prepared within the standard guidelines, are subject to review and approval by the regulatory agency. The engineer exercises usual supervision of construction for compliance with plans and specifications and upon completion of construction, is responsible for such testing and inspection as necessary to demonstrate performance according to project specifications.

III. ESTABLISHMENT OF TECHNICAL DESIGN REQUIREMENTS

In general, the interests of the Owner are represented before the regulatory agency by the Engineer selected by the Owner to solve his pollution problem. In effect, the Engineer will study the local problem, including the effluent restraints established by the regulatory agency, and evaluate the many different processes, combinations of equipment and equipment layout, and operating schemes which may be used to produce an effluent discharge that will satisfy the regulatory agency. The Engineer has a responsibility to the Owner to recommend a system that will be effective and economical. The regulatory agency has a responsibility to see that the system once it is completed does produce an effluent that meets the restraints imposed on it.

Both the Engineer and the regulatory agency personnel must consider the same basic science and engineering principles in considering solutions to a given engineering problem. Basic principles do not change, but individuals may evaluate them differently, either because they are viewing them from a different responsibility viewpoint or because they have a different background of experience. Obviously, the regulatory agency personnel and the Engineer must both be fully competent in understanding the basic principles involved in pollution control. In considering the application of a given process or piece of equipment to solution of a given problem, the Engineer and the regulatory agency must:

1. Agree on the basic scientific and engineering principles that are important in the given process
2. Arrive at design parameters (loading rates, for example) that are in agreement with accepted principles and that have been demonstrated to provide successful operation in "normal" situations.

3. Establish a check list or guideline to assure that all of the physical features (hardware standards) that need to be provided for successful operation are included in the design.

The scientific and engineering principles that are important in a given process are basic. These principles must be understood and used as a guide to what effect might reasonably be expected as the process is applied in the non-normal situation. Whenever departures from "normal" are contemplated, they should be based on an adequate statement and evaluation of the principles involved. There should be a minimum of disagreement between regulatory agency and Engineer with regard to which principles are applicable in the given instance.

Once the Engineer determines which type of system is most applicable in solving the Owner's pollution problem, the Engineer and regulatory agency must agree on the design parameters that are to be used in designing the system. Here, the regulatory agency may have more experience with both the normal and the abnormal situation than the engineer. In such cases, the regulatory agency has the responsibility for making such information and experience freely and publicly available to professional workers in the field. This may be done through issuance of in-house research and operation reports or by publication in technical journals. Such information and experience can then be evaluated for completeness and reliability by both Engineer and regulatory agency in arriving at reasonable design standards. Today, there appears to be a tendency for educators and researchers to publish and for operating experience to be buried in files where it cannot be used to generate reliable design parameters in both normal and abnormal applications.

At times, the Engineer -- or a manufacturer or researcher -- will have more experience with new processes or a particular application of an old process than the regulatory agency. Here, the Engineer and agency may develop design criteria based on principles or on pilot-plant results, recognizing that the Owner bears the ultimate responsibility for providing a system that will provide the desired degree of treatment.

Once the Engineer and agency agree on a system and its controlling principles and the design parameters to be used in the given application, the required physical features or hardware standards become obvious to the competent professional. A statement of the hardware standards to be provided for can then be used as a checklist in reviewing the design. It must never be used as the basis for the design.

In order to facilitate the agreement between Engineer and regulatory agency in departing from normal situations, the REVISED TEN STATE STANDARDS should make provisions for:

1. Stating the principles involved in the different processes used in pollution control and indicating the probable effects of the factors affecting performance.
2. Stating for each process the range of values of the design parameters found successful in "normal" applications.
3. Listing for each process the hardware facilities that are equipped or recommended for assuring adequate process performance and control.

IV. EXAMPLES OF DESIGN APPROACH

A. Purpose

In order to demonstrate the type of STANDARDS approach discussed in Chapter III, the COMMITTEE has prepared two different sections for a REVISED TEN STATE STANDARD. The first example represents a revision of Section 53 (pre-aeration and flocculation) of the current TEN STATE STANDARDS. The second example represents a partial draft of a new section to be entitled, "Aerobic Biological Treatment". It should be pointed out that neither section represents a complete and final draft for a REVISED TEN STATE STANDARDS. They are, once again, included here to demonstrate the type of approach which we recommend in revising the STANDARDS.

In the REVISED TEN STATE STANDARDS, the sections would be organized by chapters generally related to unit processes involved in treatment systems. The present standards follow this pattern. Additional chapters on sewers, pumping stations, and items not usually covered on a unit operations/process approach would also be needed.

Each chapter would be comprised of two parts:

1. The technical process data relating to performance including a discussion of the basic mechanisms or principles involved, the empirical performance criteria currently used successfully, and the relationship between fundamental mechanisms and current performance criteria. (A very difficult job to do!)
2. The "hardware" relating to the physical system needed to make the process work and to produce a physical system that can be operated effectively and economically.

B. Examples

1. Flocculation. Section 53 of the current TEN STATE STANDARDS is considered to be deficient in the following respects:

a) It does not emphasize that the purpose of the treatment (principle) involves flocculation or the promotion of the formation of larger and heavier settleable particles.

b) It does not indicate the type of wastes amenable to this treatment.

c) It does not indicate the effects of flocculation in 1) improving removal of solids and oxygen demand by settling and 2) increasing the rate of sedimentation.

d) It does not indicate precautionary measures needed to keep from destroying the floc once the flocculation takes place.

e) It does not indicate the degree of treatment achievable with "normal" wastes.

f) It does not indicate a basis for prorating detention time between flocculation and sedimentation.

An improved Section 53 on flocculation might be stated as follows:

53. Flocculation (Preaeration or Mechanical Flocculation)

The principal effect of air or mechanical agitation of wastes is to promote a flocculating action of the suspended solids in the raw waste which results in improved primary settling efficiency on the order of 5 to 10 percentage points higher removal of both BOD and suspended solids (domestic waste). The flocculation affects only the suspended solids in the waste and cannot be expected to affect the dissolved solids or, to any significant degree, the truly colloidal solids. The increased BOD and suspended solids removal is due only to the more effective sedimentation removal of the suspended solids due to their flocculation into larger more rapidly settling particles.

Perhaps even more significant to design than the increased BOD and suspended solids removal is the pronounced effect on the settling rate of the flocculated solids. The larger particles not only settle more completely; they also settle much faster. In practice, the same degree of suspended solids removal can be obtained in 15 to 20 minutes of sedimentation of a well flocculated waste as is obtained by 1½ to 2 hours of sedimentation of the same raw waste. In the design of sedimentation tanks following flocculation, therefore, both the area and depth of the sedimentation tank become important.

Flocculation of a waste can be obtained without the use of chemicals merely by the gentle agitation of the waste with mechanical devices or by preaeration. As used here, preaeration is defined as the air agitation of raw waste water for a period of 30-45 minutes prior to primary settling. Preaeration is a preparatory treatment of sewage designed to remove gases, add oxygen, promote flocculation of grease to enhance grease separation, improve grit separation, improve (raise) the ORP of normal domestic waste, and to aid the coagulation and flocculation of solids. The effectiveness of preaeration appears not to depend on method or rate of aeration, nor on the strength of the waste.

The effectiveness of mechanical agitation or preaeration depends on promoting the flocculation of larger particles <u>and the sedimentation</u> of the larger particles. To keep from breaking up the larger particles once formed, care must be exercised in handling the flocculated wastes. The velocities involved in moving the flocculated waste from one place to another must be kept low enough to keep from breaking up the floc. Preferably, flocculation and sedimentation should take place in the same tank. Plant-scale tests have shown, however, that flocculation by preaeration is most helpful when plain settling efficiency is poorest, thus providing a valuable fly-wheel effect for continuing plant performance. The extra efficiency of sedimentation following flocculation will not be consistent, since the flocculation characteristics of the waste will not be the same all the time. Preaeration and mechanical stirring will not be successful if the waste itself is not amenable to flocculation. For example, a dairy waste consisting mainly of colloidal milk solids would not benefit from such agitation. Reduction in waste strength during flocculation itself will be so slight that no credit for removal should be assigned to the flocculation process as such.

The applicability of a flocculation process can best be judged on its merits for each specific waste treatment problem. Laboratory tests should be made to determine the effectiveness of flocculation in improving the settleability of the waste being treated. Among the factors affecting the efficiency of flocculation, the most critical are the following:

1. amenability of the waste to flocculation
2. the aeration rate or the mixing speed
3. the length of the flocculation period
4. the length of settling time following flocculation.

Flocculation of waste by preaeration or by mechanical agitation, with or without use of chemicals, is worthy of consideration when it is desired:

a) to reduce the waste load on following treatment units by increasing the percentage of BOD or SS removal by primary sedimentation,
b) to take advantage of the striking effect of flocculation in increasing settling velocity by making a comparable decrease in sedimentation time in new plants,
c) to take advantage of the striking effect of flocculation in increasing settling velocity to increase the efficiency of existing overloaded primary facilities, or
d) to reduce treatment costs by combining aerated grit removal and preaeration facilities.

<u>Design Criteria</u>

53.1 Arrangement: The flocculation units should be designed so that their removal from service will not interfere with the normal operation of the remainder of the plant. In order not to break up the floc once formed, the flocculation tank should preferably be constructed as an integral part of the sedimentation tank. If flocculation and sedimentation take place in separate tanks, the transfer of flocculated waste between units should take place with velocities less than 2 ft/sec and without passage through sharp turns, falls, narrow gate openings or over weirs or through turbulent restrictions which would break up the fragile floc formed and negate the whole purpose of the treatment.

53.2 Detention Period

53.21 Coagulation: When air or mechanical agitation is used in conjunction with chemicals to coagulate or flocculate the solids in the wastewater, the detention period should be determined by laboratory tests. A detention time of about 30 minutes at design flow would be common, with few units with detention periods less than 20 minutes.

53.22 Reduced Sedimentation Time: When air or mechanical flocculation is used for the purpose of reducing sedimentation time, the flocculation detention time should be not less than 30 to 45 minutes at design flow. Generally, half the ultimate value achieved by 60 minutes of flocculation will be accomplished in the first 15 minutes of flocculation and 70 percent of this amount in the first 30 minutes. Sedimentation times with 30 minutes of flocculation should generally not be less than 30 minutes. With longer flocculation times, shorter sedimentation detention times might be employed.

53.23 BOD Reduction: When air or mechanical flocculation is used for the purpose of obtaining increased removal of BOD, the flocculation detention period should be at least 30 minutes at maximum flow and at least 45 minutes at design flow.

53.3 Flocculation Devices

Whether air or mechanical flocculation is used, the rate of agitation should be sufficient to keep the flocculent solids in suspension.

53.31 Paddles: Paddles should have a peripheral speed of 1½ to 2½ ft/sec to prevent deposition of solids.

53.32 Aerators: Any type of aeration equipment used for aerating activated sludge may be used for air flocculation. A minimum air flow rate of 0.1 cu ft/gal is needed. The rate of air supply should be adjustable upward from this minimum to match the short-term oxygen demand (domestic waste) and to provide adequate agitation to prevent deposition. Additional aeration at this point to improve DO levels is inefficient and short-lived. Aeration equipment must provide for control of the rate of aeration principally to obtain good mixing and to prevent deposition.

53.4 Details: Inlets and outlet devices should be designed to provide proper distribution, to prevent short-circuiting, and to prevent breakup of the flocculated solids.

53.5 Quick Mix: At plants where there are two or more flocculation basins utilizing chemicals, provision shall be made for a quick mix of the wastewater with the chemical so that the wastewater passing to the flocculation basins will be of uniform composition. The detention period provided in the quick-mix chamber should be very short - 1/2 to 3 minutes.

53.6 Grit Removal: Because of the certainty of grit accumulation, mechanical grit removal equipment must be provided as an integral part of the preaeration process. Special attention should be given to tank configuration to facilitate effective grit removal.

53.7 Grease Removal: Unless provided in primary settling, grease removal provision should be included in flocculation tank design.

2. Aerobic Biological Treatment. In the REVISED TEN STATE STANDARDS, Chapter 70 on Secondary Treatment would require extensive revision. The current standards are considered to be grossly inadequate in a number of areas; only a few of which will be stated:

Trickling Filters

1. The current standards include hardware requirements that are not consistent with many new developments in trickling filter, i.e. use of deeper filters with plastic media.
2. The loading parameters are based on operation of filters without recirculation, although data are available (even though much more data are needed) in the literature.
3. Recent operating data indicate the trickling filter efficiencies in winter in northern climates are significantly below those indicated in the standards. Since regulatory agencies consider winter conditions to be most critical on the stream, it seems that a stronger recommendation might be made on the need for covered filters in northern climates.

Activated Sludge

1. The current standards do not include information on the latest developments in the activated sludge process: high rate aeration, dispersed aeration, extended aeration, aerobic digestion, contact-stabilization.
2. The current standards do not include information on the latest developments in the hydraulic factors affecting process operation: plug flow vs. homogeneous systems
3. The information included is so inadequate that it is difficult to

use it for making use of the latest design and operating information.

4. In effect, the inadequacy in the activated sludge standards have penalized their use in Iowa.

An improved Chapter 70 on Aerobic Biological Treatment to replace Chapter 70 on Secondary Treatment might be stated along the lines indicated by the following:

Chapter 70
Aerobic Biological Treatment

71 Principles

71.1 General

71.11 Applicability: Aerboic biological treatment is applicable to systems treating biologically degradable, non-toxic wastes when a higher degree of treatment than afforded by preliminary or primary treatment is required. This is commonly called secondary treatment.

71.12 Characteristics: Aerobic biological treatment utilizes the ability of living organisms in a suitable environment to convert and use chemical energy in organic wastewater contaminants for their own sustenance and reproduction. The treatment effectiveness is influenced by all of the factors affecting growth and metabolism rates of heterogeneous biological populations. The effect of variable environmental conditions must be recognized when predicting results to be obtained in a given situation on the basis of results observed in other installations.

71.2 Environmental Requirements: The design must insure establishment and maintenance of suitable environmental conditions for biological activity.

71.21 Toxic materials: Toxic materials in such concentrations as to reduce the rate of biological metabolism and growth rate below that upon which predicted performance is based must be excluded from the system.

71.22 Organic waste composition: Biological reaction rates vary widely for different organic nutrients. The predicted performance and/or recommended loading data contained herein are based on organic nutrients such as found in municipal wastewater from residential and commerical areas. Wastes from other sources such as industries may support biological activity at rates greatly above or below these "normal" rates and the design must be correspondingly modified when these other wastes are to be treated.

71.23 Food characteristics: The contaminants in the wastewater to be removed by aerobic biological action constitute the food for the organism population. The food must provide the carbon and nitrogen source for energy and synthesis and the necessary trace nutrients such as calcium, phosphorous, sulfur, etc. The food must be in solution, capable of being hydrolyzed by cellular enzymes, or in small enough particles to be used directly by larger organisms capable of ingesting more complex molecules. Any departure of food characteristics from those upon which predicted results are based must be reflected in the design.

71.24 Food-organism concentration: BOD_5 is customarily used as an index of food concentration. Biological populations, reaction rates, and operational characteristics in systems treating a given waste are profoundly affected by the relative concentrations of food and organisms in the system or any portion thereof. In general, the highest degrees of treatment are obtained in those systems which are food deficient or in a late stage of declining growth in the waste-organism stream prior to leaving the system. Systems which involve a constantly shifting ratio of food to organisms must provide sufficient reaction time to accomodate the lag and growth phenomena associated with such changes. Traditional loading parameters used in empirical design and operating procedures are frequently not true indices of the real food/organism load in a given part of the system.

71.25 Free oxygen: Aerobic biological processes require free oxygen in the waste-organism system. The usual source of oxygen is air and oxygen usually passes from the air to the metabolic end product via solution in the liquid. The design must provide for transfer of sufficient oxygen from the air to the liquid so that the biological reaction is not limited by oxygen availability.

71.26 Temperature: Rates of aerobic biological reactions are greatly affected by temperature, varying by a factor of approximately 2 for each 10^{o} C change in water temperature. Predicted results and design must be adjusted to the critical temperature expected in the given installation.

71.27 pH: Biological population characteristics are influenced by the pH of the environment. The populations producing results usually used as a basis for performance prediction in normal systems are characteristic of pH from 6.5 to 8.5. Environmental pH outside this range will result in different population characteristics and reaction rates. Shifts in pH during operation may require long periods for acclimitization. In such cases, chemical control of pH is indicated.

71.28 Hydraulic loading and reaction time: In general, available reaction time is determined by the hydraulic loading of the system. Hydraulic loadings which reduce reaction time below that in systems whose results are used to predict performance create different environmental conditions which must be reflected in the design.

71.29 Variable loading: Variations in food and hydraulic loading produce environmental changes affecting the performance of biological systems. The design must regulate these variations or provide sufficient capacity to allow the system to adapt itself when the magnitude of the changes is such as to affect adversely the performance.

71.30 Applications: Activated sludge and trickling filters are the usual systems for utilizing the principles of aerobic biological treatment. Stabilization ponds or lagoons are facultative systems which may employ, in part, some of the principles of aerobic treatment.

72 Activated Sludge

72.1 General

72.11 Description of process: The activated sludge process depends on the generation and maintenance of a biological culture which is mixed with influent, allowed to react in aeration tanks in the presence of dissolved oxygen, removed from the stream following aeration, usually by sedimentation, and returned to the process. For any given waste the process kinetics and performance depend upon the environmental conditions produced in the system.

72.12 Oxygen: Air is the usual source of oxygen. Oxygen may be transferred to the mixed liquor by introducing air to the aeration tank by any method capable of exchanging oxygen between the air and the mixed liquor in sufficient quantity to maintain the mixed liquor dissolved oxygen concentration at not less than 2 mg/l.

72.13 Waste sludge: Waste sludge is the net product of biological synthesis, endogenous loss and accumulated non-degradable solids. It represents blowdown from the system needed to limit the total solids in the system to any given level. Blowdown, or wasting, may be accomplished by loss in the plant effluent, by controlled wasting from the mixed liquor or return sludge stream or by both methods. Systems capable of supporting high solids concentrations in the mixed liquor will have less waste sludge than those with lower solids concentrations because of more nearly equal rates of synthesis and endogenous loss. All systems, however, must waste sludge to control solids build-up due to non-degradable solids. Since selective wasting of degradable and non-degradable solids is not possible, the waste sludge will always contain the same ratio of degradable to non-degradable solids as in the stream from which it is taken. It is important that the effect on effluent quality of sludge wasting in the plant effluent be recognized when this method of wasting is employed.

72.2 Modifications: Aerobic biological treatment by activated sludge is used in various modifications in which the principle differences are related to hydraulic and food/organism environmental conditions. The usual hydraulic or flow modifications include the plug flow system, the step aeration system, and the completely mixed or homogeneous system. The usual process modifications include the conventional process, dispersed aeration, high rate, activated sludge, extended aeration, and contact stabilization.

72.21 Batch or plug flow; traditional or conventional system: In the conventional plug flow hydraulic system, return sludge and influent are combined at the inlet end of a longitudinal flow tank and the mixture proceeds essentially as a batch with minor intermixing through the length of the tank. Travel is usually in a spiral pattern induced by air applied through diffusers along one side of the tank. The biological character of the return sludge is that associated with the lowest food concentration in the system. It is mixed with the influent and must acclimate to the highest food concentration in the system before effective metabolism commences. The biological population must then shift from this high food concentration to the low food concentration character of the effluent as metabolism proceeds during travel of the batch through the tank. The aeration tank must provide sufficient residence time for the acclimatization and metabolism processes to be completed under the most adverse food/organism ratio expected at the influent end of the aeration tank. The aeration system must be capable of transfering sufficient oxygen to satisfy biological uptake while maintaining at least 2 mg/l of dissolved oxygen in the mixed liquor and must maintain sufficient transverse velocity to keep the mixed liquor solids in suspension. The rate of oxygen uptake will be highest near the inlet end of the tank where food concentration is highest and where metabolism proceeds at the highest rate after return sludge acclimatization. Provision for varying the rate of aeration along the length of the tank (tapered aeration) to match the variable oxygen uptake rate is recommended.

72.22 Step aeration system: A modification of the traditional plug flow system in which the influent is added incrementally along a portion of the aeration tank length. The first portion of the tank may be used for reaeration of return sludge to achieve utilization of adsorbed but unmetabolized nutrient which may be contained in the sludge. Distribution of the influent over a greater portion of the tank length reduces the shock effect inherent in the traditional system and distributes the oxygen demand more uniformily along the length of the tank. The food/organism concentration regime is intermediate between the traditional plug flow system and the completely mixed or homogeneous system.

72.23 Completely mixed or homogeneous system: In this hydraulic system, the influent and return sludge are dispersed throughout the entire volume of the aeration tank immediately upon entering the tank. The composition of the mixed liquor is, therefore, homogeneous throughout the aeration tank. The composition of the mixed liquor leaving the tank is the same as that everywhere in the tank. The food/organism ratio is the same in all parts of the system and acclimatization to shifting food concentrations is not required. Oxygen uptake rate is uniform throughout the aeration tank. The mixing needed for dispersion of the influent and return sludge streams can be provided by the aeration system alone or in conjunction with mechanical mixing devices.

72.24 Dispersed aeration; high rate activated sludge: A system operated at a high food/organism ratio such that log growth or an unlimited food environment prevails. The system may be employed when an intermediate degree of treatment is desired but difficulty with separation of the mixed liquor solids from the effluent by sedimentation may be encountered due to the high energy state associated with the high food/organism ratio.

72.25 Conventional activated sludge: A system that is operated at a high food/organism ratio (high rate growth) at the influent end of the tank and at a lower food/organism ratio (near beginning of endogenous respiration) at the effluent end of the tank. The degree of treatment obtained is determined by the final ratio of food/organism maintained at the tank outlet.

72.26 Extended aeration: An homogeneous system providing a long (24 hour) aeration period with a very low food/organism ratio. The system is customarily operated such that the only sludge wasting is by loss of solids in the effluent and the sludge solids concentration in the system is allowed to stabilize at the level corresponding to the composite effect of synthesis, endogenous loss and loss in the effluent. Loss in the effluent is related to the efficiency of the final settling tank.[76]

72.27 Contact stabilization: A stage system consisting of a short contact-aeration period of return sludge and influent followed by final settling and reaeration (stabilization-aeration) of the return sludge to insure assimilation of the material adsorbed by the sludge mass but not metabolized during the contact period.

72.3 Loading parameters: Traditional loading parameters are aeration period, as defined by effective tank volume and influent rate of flow, volumetric BOD loading rate and the BOD loading rate per unit of volatile suspended solids. Customary values of these parameters cited herein are those observed in successful operation and are applicable only to similar environmental situations. These parameters are not necessarily true measures of environmental conditions, particularly with respect to the food/organism ratios.

72.31 Aeration period: For various modifications based on design rate of influent flow and tank volumes, minimum as follows:

Conventional activated sludge - 6 hours (Sec. 72.25)

Step aeration - 3 hours (Sec. 72.22)

Homogeneous - As required for effluent quality

72.32 Volumetric BOD loading: For various process modifications based on 5-day BOD of the influent, maximum as follows:

Traditional - 35 pounds of BOD per day per 1000 cu.ft. (Sec. 72.25)

Step aeration - 50 pounds of BOD per day per 1000 cu.ft. (Sec. 72.22)

Homogeneous - 125 pounds of BOD per day per 1000 cu.ft.

72.43 Dispersed aeration: This is a special purpose modification with very limited application that should be reviewed on its merits for a given installation.

V. AN APPROACH TO INNOVATIONS

As indicated in the introduction, Section 43.2 of the current TEN STATE STANDARDS (entitled New Processes, Methods, and Equipment) actually tends to discourage use of new technology in water pollution control. Innovation should be encouraged where technically and economically indicated as long as the Owner recognizes his obligation to produce an effluent which meets, and can continue to meet, the standard established by the regulatory agency. The regulatory agency should be responsible for establishing the effluent standard and should see that the effluent is monitored to assure that the effluent standard is met. The regulatory agency should specify the effluent standard but not the physical facilities used by the Owner in producing an effluent that meets that standard. The regulatory agency should, however, review and approve the Owners plans for the facilities.

In order to clarify the role of the parties concerned in so far as innovations are involved, the COMMITTEE believes the following restatement of Section 43.2 should be adopted:

43.2 Innovations in methods and procedures for waste treatment:

43.21 The policy of the reviewing authority is to encourage, rather than to obstruct, development of innovations in methods and procedures for the advancement of water pollution control technology.

43.22 It is the responsibility of the engineer and the manufacturer or developer of the innovation to demonstrate to the reviewing authority and the owner how the innovation will produce and maintain the environment for successful operation and to reasonably assure performance and dependability within local treatment objectives established by the state water quality criteria.

43.23 It is the responsibility of the owner to assure the reviewing authority that he is willing to participate in the demonstration and use of any such innovations that may be requested and that he recognizes his obligation to provide additional facilities if the innovation does not perform as expected.

43.24 The owner shall further require that his engineer and/or manufacturer or developer demonstrate actual performance of such technological innovations, including the establishment of operating procedures and techniques, together with laboratory confirmation of such performance.

43.25 The engineer shall be responsible for the evaluation of the functional efficiency of equipment and shall furnish the reviewing authority with such evidence to substantiate the claims of performance.

VI. COMMITTEE RECOMMENDATIONS

The COMMITTEE to Study Engineering Design Standards, on the basis of its review of the current TEN STATE STANDARDS, concludes and recommends the following:

1. The current TEN STATE STANDARDS are seriously inadequate for use as design standards in their present form. The STANDARDS should be updated and modified as suggested by the sample sections included in this report.
2. The revision of the TEN STATE STANDARDS to incorporate principles, design parameters, and hardware standards (as recommended above) is a herculean task which should not be attempted by a "volunteer" committee. The Iowa Water Pollution Control Commission should request that the TEN STATES involved and the FEDERAL WATER POLLUTION CONTROL COMMISSION employ a group of competent engineers and scientists representing regulatory agencies, consulting engineers, Owners (operators), equipment manufacturers, and educators to prepare a REVISED STANDARD FOR WATER POLLUTION CONTROL FACILITIES that adequately represents the current STATE OF THE ART.
3. The Iowa Water Pollution Control Commission should establish a Technical Advisory Group which the professional personnel of the Commission can consult with concerning applications of new technology in solving Iowa's water pollution problems.
4. The Iowa Water Pollution Control Commission should follow the policies included in the proposed statement of the FOREWORD in considering approval of plans and specifications for solving pollution problems.