

GERMAN **ATV-DVWK** RULES AND STANDARDS

STANDARD ATV-DVWK-A 131E

Dimensioning of Single-Stage Activated Sludge Plants

May 2000

GERMAN **ATV-DVWK** RULES AND STANDARDS

STANDARD ATV-DVWK-A 131E

Dimensioning of Single-Stage Activated Sludge Plants

May 2000

ISBN 978-3-935669-96-2



Publisher/Marketing:

Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e. V.

German Association for Water, Wastewater and Waste

Theodor-Heuss-Allee 17 • 53773 Hennef • Germany

Tel.: +49 2242 872-333 • Fax: +49 2242 872-100

E-Mail: kundenzentrum@dwa.de • Internet: www.dwa.de

Preparation

This ATV Standard has been elaborated by the ATV-DVWK Specialist Committees KA 5 and KA 6.

Specialist Committee KA 5 "Settling Processes" has the following members

Prof. Dr.-Ing. Günthert, München (Chairman)	Dr.-Ing. Resch, Weissenburg
Prof. Dr.-Ing. Billmeier, Köln	Prof. Dr.-Ing. Rosenwinkel, Hannover
Dipl.-Ing. Born, Kassel	Dr.-Ing. Rölle Stuttgart
Dr.-Ing. Andrea Deininger, Weyarn	Dr.-Ing. Schulz, Essen
Dr.-Ing. Grünebaum, Essen	Prof. Dr.-Ing. Seyfried, Hannover
Dr.-Ing. Kalbskopf, Dinslaken	Dr.-Ing. Stein, Emsdetten

Specialist Committee KA 6 "Aerobic Biological Wastewater Treatment Processes" has the following members

Prof. Dr.-Ing. Kayser, Braunschweig (Chairman)	Dr. Lemke, Leverkusen
Dipl.-Ing. Beer, Cottbus	Dr. Hilde Lemmer, München
Dr.-Ing. Bever, Oberhausen	Prof. Dr.-Ing. Londong, Wuppertal
Prof. Dr.-Ing. Bode, Essen	Prof. Dr. Matsché, Wien
Dr.-Ing. Boll, Hannover	Dipl.-Ing. Peter-Fröhlich, Berlin
Prof. Dr.-Ing. Gujer, Zürich	Prof. Dr.-Ing. Rosenwinkel, Hannover
Prof. Dr. rer. nat. Huber, München	Dipl.-Ing. Schleypen, München
Prof. Dr.-Ing. E.h. Imhoff, Essen	Dr.-Ing. Teichgräber, Essen
Prof. Dr.-Ing. Krauth, Stuttgart	Dipl.-Ing. Ziess, Haan-Gruiten

Die Deutsche Bibliothek [The German Library] - CIP-Einheitsaufnahme

ATV-DVWK Standard
A 131E. Dimensioning of Single-Stage Activated Sludge Plants. – 2000
ISBN 3-935669-96-8

All rights, in particular those of translation into other languages, are reserved. No part of this Standard may be reproduced in any form - by photocopy, microfilm or any other process - or transferred into a language usable in machines, in particular data processing machines, without the written approval of the publisher.

© GFA-Gesellschaft zur Förderung der Abwassertechnik e.V.
(Publishing Company of ATV-DVWK, Water, Wastewater, Waste), Hennef 2000)

Original German edition produced by: DCM, Meckenheim

Contents

PREPARATION..... 2

NOTES FOR USERS..... 5

FOREWORD..... 5

1 AREA OF APPLICATION..... 6

1.1 PREAMBLE..... 6

1.2 OBJECTIVE 6

1.3 SCOPE 6

2 SYMBOLS 7

3 PROCESS DESCRIPTION AND PROCEDURE OF DIMENSIONING..... 11

3.1 GENERAL..... 11

3.2 BIOLOGICAL REACTOR 13

3.3 SECONDARY SETTLING TANK 15

3.4 PROCEDURE OF DIMENSIONING..... 16

4 DIMENSIONING FLOWS AND LOADS 18

4.1 LOADING WITH WASTEWATER..... 18

4.2 LOADING WITH SLUDGE LIQUOR AND EXTERNAL SLUDGE 20

5 DIMENSIONING OF THE BIOLOGICAL REACTOR..... 20

5.1 DIMENSIONING ON THE BASIS OF PILOT EXPERIMENTS..... 20

5.2 DIMENSIONING ON THE BASIS OF EXPERIENCE..... 21

5.2.1 *Required Sludge Age* 21

5.2.1.1 Plants without Nitrification 21

5.2.1.2 Plants with Nitrification 22

5.2.1.3 Plants with Nitrification and Denitrification 23

5.2.1.4 Plants with Aerobic Sludge Stabilisation 24

5.2.2 *Determination of the Proportion of the Reactor Volume for Denitrification*..... 24

5.2.3 *Phosphorus Removal*..... 26

5.2.4 *Determination of the Sludge Production*..... 27

5.2.5 *Assumption of the Sludge Volume Index and the Mixed Liquor Suspended Solids Concentration* 28

5.2.6 *Volume of the Biological Reactor*..... 30

5.2.7 *Required Recirculation and Cycle Time*..... 31

5.2.8 *Oxygen Transfer*..... 31

5.2.9 *Alkalinity*..... 34

5.3 DIMENSIONING OF AN AEROBIC SELECTOR 35

6 DIMENSIONING OF THE SECONDARY SETTLING TANK..... 35

6.1 APPLICATION LIMITS AND EFFLUENT CHARACTERISTICS 35

6.2 SLUDGE VOLUME INDEX AND PERMITTED THICKENING TIME 36

6.3 SUSPENDED SOLIDS CONCENTRATION IN THE RETURN SLUDGE 37

6.4 RETURN SLUDGE RATIO AND SUSPENDED SOLIDS CONCENTRATION IN THE INFLUENT TO THE SECONDARY SETTLING TANK 38

6.5 SURFACE OVERFLOW RATE AND SLUDGE VOLUME SURFACE LOADING RATE 39

6.6 SETTLING TANK SURFACE AREA..... 40

6.7 SETTLING TANK DEPTH..... 40

6.8 TESTING AND RECALCULATION OF EXISTING SECONDARY SETTLING TANKS 43

6.9	DESIGN OF THE SLUDGE REMOVAL SYSTEM	43
6.9.1	<i>Sludge Removal and Scraper Design</i>	43
6.9.2	<i>Short-Circuit Sludge Flow Rate and Solids Balance</i>	44
6.9.3	<i>Sludge Removal in Horizontal Flow Circular Tanks</i>	44
6.9.4	<i>Sludge Removal in Rectangular Tanks</i>	45
6.9.5	<i>Verification of the Solids Balance</i>	46
7	PLANNING AND OPERATING ASPECTS	46
7.1	BIOLOGICAL REACTOR (AERATION TANK)	46
7.1.1	<i>Tank Design</i>	46
7.1.2	<i>Accumulation of Foam and Floating Sludge</i>	47
7.1.3	<i>Regulation of the Pumps for Internal Recirculation</i>	47
7.1.4	<i>Nitrite Formation in Plants not Dimensioned for Nitrification</i>	47
7.2	SECONDARY SETTLING TANKS	47
7.2.1	<i>General</i>	47
7.2.2	<i>Mainly Horizontal flow Tanks</i>	47
7.2.3	<i>Mainly Vertical flow Tanks</i>	48
7.3	RETURN SLUDGE	49
8	DYNAMIC SIMULATION	50
9	COSTS AND ENVIRONMENTAL EFFECTS	51
10	RELEVANT [GERMAN] REGULATIONS, DIRECTIVES AND STANDARD SPECIFICATIONS	51
	LITERATURE	53
	APPENDIX	
	DETERMINATION OF THE SLUDGE PRODUCTION AND THE OXYGEN CONSUMPTION FOR CARBON REMOVAL ON THE BASIS OF THE COD	55
A1	DIMENSIONING PRINCIPLES	55
A2	COD BALANCE	55
A3	CALCULATION OF THE SLUDGE PRODUCTION	57
A4	CALCULATION OF THE OXYGEN UPTAKE	57

Notes for Users

This ATV-DVGW Standard is the result of honorary, technical-scientific/economic collaboration which has been achieved in accordance with the principles applicable therefore (statutes, rules of procedure of the ATV and ATV Standard ATV-A 400). For this, according to precedents, there exists an actual presumption that it is textually and technically correct and also generally recognised.

The application of this Standard is open to everyone. However, an obligation for application can arise from legal or administrative regulations, a contract or other legal reason.

This Standard is an important, however, not the sole source of information for correct solutions. With its application no one avoids responsibility for his own action or for the correct application in specific cases; this applies in particular for the correct handling of the margins described in the Standard.

Foreword

At the time of elaborating the previous issue of this ATV Standard (1988-90) there were only isolated activated sludge plants with nitrogen and phosphorus removal, from whose operating results information could be deduced for dimensioning and operation. Therefore, with many questions, one had to rely exclusively on the results of research. In the meantime, a large number of such facilities have been commissioned so that a wider database, also from practice, is available for a revision.

Compared with the issue of ATV Standard ATV-A 131 dated February 1991 the following important changes have been made:

- validity for activated sludge plants of any size (up to now $\geq 5,000$ total number of inhabitants and population equivalents PT).
- the chapter on derivation of design flows and loads is taken out, since a separate ATV Standard is to be elaborated for all types of wastewater treatment processes.
- dimensioning temperature for nitrogen removal $T = 12^\circ \text{C}$ in accord with the requirements from Appendix 1 of The [German] Wastewater Ordinance (AbwV) (previously $T = 10^\circ \text{C}$), under the assumption of a flexible design of the biological reactor.
- integration of dimensioning for excess biological phosphorus removal.
- modification of the denitrification capacity.
- change of the determination of the required oxygen transfer.
- integration of the dimensioning of an aerobic selector.
- option for dimensioning on the basis of the chemical oxygen demand (COD).
- increase of the permitted sludge volume loading rate of secondary settling tanks.
- modification of the designation of partial depths and the determination of the depth of the thickening and sludge removal zone of secondary settling tanks.
- integration of the dimensioning of the sludge removal systems (scrapers) in secondary settling tanks.

Explanations on process technology are to be taken from the ATV Manuals "Biological and advanced wastewater treatment" [1] and "Mechanical wastewater treatment" [2]. The figures additionally mentioned in the text refer to the chapters of the manuals.

1 Area of Application

1.1 Preamble

The treatment of the stormwater in the sewer network and of wastewater in the wastewater treatment plant form one unit for the protection of surface waters. For the dimensioning of the wastewater treatment plant and the stormwater overflows the planning periods are to be matched to each other. The planning period should comprise not more than 25 years.

1.2 Objective

Using the dimensioning values recommended in this standard, for municipal wastewater one can, with single-stage activated sludge plants, meet the achievable minimum effluent requirements which correspond with or undercut the requirements of the [German] Wastewater Ordinance (AbwV) dated 02.09.99, Appendix 1, and the associated sampling regulations. If commercial or industrial wastewater with high fractions of slowly biodegradable and/or inert organic substances is discharged, a higher residual COD than with domestic wastewater can arise. The same applies for areas with low water consumption and a low infiltration rate, as then the inert COD concentration increases.

Technical regulations are drawn up for the selection of the most practical procedure for carbon, nitrogen and phosphorus removal, and for the dimensioning of the essential components and facilities of the plant. The selection and dimensioning of aeration equipment is not dealt with in this standard.

Since this standard is also applied outside Germany and because locally even stricter requirements can be set, it is not aimed exclusively at the observance of the effluent requirements laid down in Appendix 1 of the Wastewater Ordinance (AbwV).

In accord with the requirements under water law, the structural and operating requirements and the sensitivity of the surface waters the planning through parallel units, reserve equipment etc. is to be oriented towards an appropriately high operational safety.

A prerequisite for the secure function of the plant, planned in accordance with this standard, is that sufficiently qualified, trained and permanently technically supported operating personnel are employed and involved in the planning process, comp. ATV Advisory Leaflet ATV-M 271 „Personalbedarf für den Betrieb kommunaler Kläranlagen“ [Personnel requirement for the operation of municipal sewage treatment plants].

1.3 Scope

This standard basically applies for the dimensioning of single-stage activated sludge plants. Due to the peculiarities of smaller sewage treatment plants attention is drawn to ATV Standards ATV-A 122E and ATV-A 126E as well as DIN 4261.

The standard applies for wastewater which essentially originates from households or from plants which serve commercial or agricultural purposes, insofar as the harmfulness of this wastewater can be reduced by means of biological processes with the same success as with wastewater from households.