

**STANDARDS OF THE
TUBULAR EXCHANGER
MANUFACTURERS ASSOCIATION**



ELEVENTH EDITION

TUBULAR EXCHANGER MANUFACTURERS ASSOCIATION, INC.
Richard C. Byrne, Secretary
www.tema.org

i

For more information or to order contact:
Infodoc Srl | www.infodoc.it | Email: prodotti@infodoc.it

NO WARRANTY
EXPRESSED OR IMPLIED

The Standards herein are recommended by The Tubular Exchanger Manufacturers Association, Inc. to assist users, engineers, and designers who specify, design, and install tubular exchangers. These standards are based upon sound engineering principles, research, and field experience in the manufacture, design, installation, and use of tubular exchangers. These standards may be subject to revision as further investigation or experience may show is necessary or desirable. Nothing herein shall constitute a warranty of any kind, expressed or implied, and warranty responsibility of any kind is expressly denied.

TEMA is a trademark of the Tubular Exchanger Manufacturers Association, Inc.

Copyright © 2023 Tubular Exchanger Manufacturers Association, Inc. - All rights reserved. This book or any part thereof may not be reproduced in any form without the written permission of the publisher. Unauthorized copies are subject to statutory penalties of \$750 to \$30,000 plus additional penalties. Published in the United States of America.

**MEMBERS OF THE
TUBULAR EXCHANGER MANUFACTURERS ASSOCIATION, INC.**

Comprising Manufacturers of Various Types of Shell and Tube Heat Exchanger Equipment

<u>Alabama Heat Exchangers, Inc.</u>	5751 LaRue Steiner Road Theodore, Alabama 36582
<u>Brask, Inc.</u>	2300 Louis Alleman Parkway Sulphur, LA 70663
<u>Cust-O-Fab, Inc.</u>	8888 West 21 st Street Sand Springs, OK 74063
<u>Dunn Heat Exchangers, Inc.</u>	410 21 st Street South Texas City, TX 77592-3028
<u>Energy Exchanger Company</u>	1844 N Garnett Road Tulsa, OK 74116
<u>Fabsco Shell and Tube, L.L.C</u>	P.O. Box 988 Sapulpa, OK 74066
<u>Graham Corporation</u>	20 Florence Avenue Batavia, NY 14020
<u>Heat Transfer Equipment Co.</u>	1515 N 93 rd E Avenue Tulsa, OK 74115
<u>Hughes-Anderson Heat Exchangers, Inc.</u>	PO Box 582710 Tulsa, OK 74158
<u>Kennedy Tank & Manufacturing Co., Inc.</u>	833 East Sumner Avenue Indianapolis, IN 46227
<u>Krueger Engineering & Mfg. Co. Inc.</u>	12001 Hirsch Rd. Houston, TX 77050
<u>Joseph Oat Corporation</u>	2500 Broadway Camden, NJ 08104
<u>Ohmstede, Ltd.</u>	895 N Main St. Beaumont, TX 77701
<u>Perry Products Corp.</u>	25 Hainesport Mt. Laurel Road Hainesport, NJ 08036
<u>RAS Process Equipment</u>	324 Meadowbrook Road Robbinsville, NJ 08691
<u>Southern Heat Exchanger Corporation</u>	P.O. Box 1850 Tuscaloosa, AL 35403
<u>Thermal Engineering International (USA) Inc. – Struthers Wells</u>	18000 Studebaker Road, Suite 400 Cerritos, CA 90703
<u>Ward Vessel and Exchanger Corporation</u>	P.O. Box 44568 Charlotte, NC 28215

TUBULAR EXCHANGER MANUFACTURERS ASSOCIATION

CONTRIBUTING MEMBER COMPANIES AND TECHNICAL COMMITTEE MEMBERS

Brask Inc.	Sangeeta Bakshi Jay Hennessey
Energy Exchanger Co.	Miles Duvall
Graham Corporation.....	Pete Brade
Heat Transfer Equipment Co.....	Kyle Stein
Hughes-Anderson Heat Exchangers, Inc.	Jerry Barham
Kennedy Tank & Manufacturing Co., Inc.	JD Smith
Joseph Oat Corporation	Lawrence Bower
Ohmstede, Ltd.....	Wade Armer
Perry Products Corp.....	Ashok Shah
RAS Process Equipment.....	Jeff Polizzi
Southern Heat Exchanger Corporation	Jeremy Wolfe
Thermal Engineering International (USA) Inc.	Garo Hamzoian
Ward Vessel and Exchanger Corp.	Bill Huffman

PREFACE

Eleventh Edition – 2023

The Eleventh Edition of the TEMA Standards was prepared by the Technical Committee of the Tubular Exchanger Manufacturers Association. Sections have been added to provide direction concerning the design of one pass floating heads and Type-D high pressure channel closures. The Eleventh Edition introduces an Exchanger Type Selection Guide which discusses the benefits and disadvantages of various types of exchangers and a section on Inspection which has information concerning non-destructive examination techniques and recommendations for their use for shell and tube heat exchangers. This edition includes new appendices for Repairs and Alterations of Heat Exchangers; for Clad and Overlay Construction; and for Installation, Operation, and Maintenance of Shell and Tube Heat Exchangers. TEMA has modified the Heat Exchanger Specification Sheet to better define the design requirements necessary to specify a heat exchanger. This Standard has been revised to include weld calculations for vertical support lugs, a clarification to the mitigation of erosion of the tube ends due to certain tube side flows, and a more detailed discussion concerning tube to tubesheet joints.

One of the main goals of the Eleventh Edition is to better present the TEMA Standards to all users. To do this, content has been expanded to include separate tables and graphics with metric units for more clarity and to provide units that make practical sense for manufacturers. The editor acknowledges the contributions of Raj Chhatrapati, M. Venkatesh, Sarath Kumar, and Parikshit Padture in this effort. Their insight and help are very much appreciated.

The editor acknowledges with appreciation the many years of service and contributions of Sam Davis and Cris Smelley to the TEMA Technical Committee.

Miles Duvall, Editor

CONTENTS

Section	Page
	MEMBERSHIP LIST..... iii
	TECHNICAL COMMITTEE..... iv
	PREFACE v
	NOTES TO USERS..... viii
1 N	NOMENCLATURE
1	Size Numbering and Type Designation—Recommended Practice 1-1
2	Nomenclature of Heat Exchanger Components..... 1-5
3	Definitions 1-8
2 F	FABRICATION TOLERANCES
1	External Dimensions, Nozzle and Support Locations 2-1
2	Recommended Fabrication Tolerances 2-2
3	Tubesheets, Partitions, Covers, and Flanges 2-4
4	Flange Face Permissible Imperfections 2-5
5	Peripheral Gasket Surface Flatness 2-7
3 G	GENERAL FABRICATION AND PERFORMANCE INFORMATION
1	Heat Exchanger Specification Sheets 3-1
2	Inspection and Shop Operation 3-1
3	Nameplates..... 3-11
4	Drawings and Code Data Reports 3-11
5	Guarantees 3-12
6	Preparation of Heat Exchangers for Shipment..... 3-13
7	General Construction Features of TEMA Standard Heat Exchangers 3-14
4 E	INSTALLATION, OPERATION, AND MAINTENANCE
1	Performance of Heat Exchangers 4-1
2	Installation of Heat Exchangers 4-1
3	Operation of Heat Exchangers..... 4-2
4	Maintenance of Heat Exchangers..... 4-4
5	Changes to Configuration of Heat Exchangers..... 4-8
5 RCB	MECHANICAL STANDARDS TEMA CLASS RCB HEAT EXCHANGERS
1	Scope and General Requirements 5.1-1
2	Tubes..... 5.2-1
3	Shells and Shell Covers..... 5.3-1
4	Baffles and Support Plates 5.4-1
5	Floating End Construction..... 5.5-1
6	Gaskets..... 5.6-1
7	Tubesheets 5.7-1
8	Flexible Shell Elements..... 5.8-1
9	Channels, Covers, and Bonnets 5.9-1
10	Nozzles 5.10-1
11	End Flanges and Bolting..... 5.11-1
6 V	FLOW INDUCED VIBRATION
1	Scope and General..... 6-1
2	Vibration Damage Patterns 6-1
3	Failure Regions..... 6-1
4	Dimensionless Numbers 6-2
5	Natural Frequency 6-3
6	Axial Tube Stress..... 6-9
7	Effective Tube Mass 6-9
8	Damping 6-12

CONTENTS

Section		Page
6	V FLOW INDUCED VIBRATION (continued)	
	9 Shell Side Velocity Distribution	6-15
	10 Estimate of Critical Flow Velocity	6-18
	11 Vibration Amplitude.....	6-20
	12 Acoustic Vibration	6-22
	13 Design Considerations.....	6-26
	14 Selected References.....	6-28
7	T THERMAL RELATIONS	
	1 Scope and Basic Relations	7-1
	2 Fouling.....	7-2
	3 Fluid Temperature Relations.....	7-4
	4 Mean Metal Temperatures of Shell and Tubes	7-23
8	P PHYSICAL PROPERTIES OF FLUIDS	
	1 Fluid Density	8-1
	2 Specific Heat.....	8-1
	3 Heat Content	8-2
	4 Thermal Conductivity	8-2
	5 Viscosity.....	8-2
	6 Critical Properties	8-3
	7 Properties of Gas and Vapor Mixtures.....	8-3
	8 Selected References.....	8-3
9	D GENERAL INFORMATION	
	(See detailed Table of Contents)	9-1
10	RGP RECOMMENDED GOOD PRACTICE	
	G-7.1.1 Horizontal Vessel Supports.....	10-2
	G-7.1.2 Vertical Vessel Supports.....	10-18
	G-7.2 Lifting Lugs	10-28
	G-7.3 Wind and Seismic Design.....	10-32
	RCB-2 Plugging Tubes in Tube Bundles	10-32
	RCB-4 Entrance and Exit Areas	10-32
	RCB-7 Tubesheets	10-39
	RCB-10.6 Nozzle Loadings	10-42
	RCB-11.5 Flange Design.....	10-42
	RCB-12 Finite Element Analysis Guidelines	10-43
	T-2 Fouling.....	10-44
	Appendix A – TUBESHEETS	A-1
	Appendix B – REPAIRS AND ALTERATIONS OF HEAT EXCHANGERS.....	B-1
	Appendix C – GUIDELINES FOR CLAD AND OVERLAY CONSTRUCTION	C-1
	Appendix D – INSTALLATION, OPERATION, AND MAINTENANCE MANUAL	D-1

NOTES TO USERS OF THE TEMA STANDARDS

Three classes of Mechanical Standards, R, C, and B, reflecting acceptable designs for various service applications, are presented. The user should refer to the definition of each class and choose the one that best fits the specific need.

Corresponding subject matter in the three classes of Mechanical Standards is covered by paragraphs identically numbered except for the class prefix letter. Paragraph numbers preceded by RCB indicates that all three classes are identical. Any reference to a specific paragraph must be preceded by the class designation.

The Recommended Good Practice section has been prepared to assist the designer in areas outside the scope of the basic Standards. Paragraphs in the Standards having additional information in the RGP section are marked with an asterisk (*). The reference paragraph in the RGP section has the identical paragraph number, but with an "RGP" prefix.

It is the intention of the Tubular Exchanger Manufacturers Association that this edition of its Standards may be used beginning with the date of issuance, and that its requirements supersede those of the previous edition six months from such date of issuance, except for heat exchangers contracted for prior to the end of the six month period. For this purpose, the date of issuance is February 1, 2024.

This Standard has both US Customary (USC) and SI units. A single system of units shall be used for all aspects of design and fabrication except where otherwise permitted by this Standard. Where not specified, and unless otherwise indicated, dimensions in USC tables are in inches, and dimensions in SI tables are in millimeters. When presented together in tables, figures, and text, SI values are presented in parentheses following the USC values and do not always indicate direct conversions. Tables with an M suffix use SI units and immediately follow the corresponding USC table; they are not referenced separately in text. Examples of this methodology may be found in Appendix GG of the ASME Boiler and Pressure Vessel Code, Section VIII.

Questions by registered users on interpretation of the TEMA Standards should be submitted online at www.tema.org. Questions requiring development of new or revised technical information will only be answered through an addendum or a new edition of the Standards.

Upon agreement between purchaser and fabricator, exceptions to TEMA requirements are acceptable. An exchanger may still be considered as meeting TEMA requirements as long as the exception is documented.