

Rotor Repair

Downstream Segment

API RECOMMENDED PRACTICE 687
FIRST EDITION, SEPTEMBER 2001

REAFFIRMED: JANUARY 2009



SPECIAL NOTES

API publications necessarily address problems of a general nature. With respect to particular circumstances, local, state, and federal laws and regulations should be reviewed.

API is not undertaking to meet the duties of employers, manufacturers, or suppliers to warn and properly train and equip their employees, and others exposed, concerning health and safety risks and precautions, nor undertaking their obligations under local, state, or federal laws.

Information concerning safety and health risks and proper precautions with respect to particular materials and conditions should be obtained from the employer, the manufacturer or supplier of that material, or the material safety data sheet.

Nothing contained in any API publication is to be construed as granting any right, by implication or otherwise, for the manufacture, sale, or use of any method, apparatus, or product covered by letters patent. Neither should anything contained in the publication be construed as insuring anyone against liability for infringement of letters patent.

Generally, API standards are reviewed and revised, reaffirmed, or withdrawn at least every five years. Sometimes a one-time extension of up to two years will be added to this review cycle. This publication will no longer be in effect five years after its publication, unless as an operative API standard or, where an extension has been granted, upon republication. Status of the publication can be ascertained from the API Downstream Segment Telephone (202) 682-8000]. A catalog of API publications and materials is published annually and updated quarterly by API, 1220 L Street, N.W., Washington, D.C. 20005.

This document was produced under API standardization procedures that ensure appropriate notification and participation in the developmental process and is designated as an API standard. Questions concerning the interpretation of the content of this standard or comments and questions concerning the procedures under which this standard was developed should be directed in writing to the standardization manager, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005. Requests for permission to reproduce or translate all or any part of the material published herein should also be addressed to the general manager.

API standards are published to facilitate the broad availability of proven, sound engineering and operating practices. These standards are not intended to obviate the need for applying sound engineering judgment regarding when and where these standards should be utilized. The formulation and publication of API standards is not intended in any way to inhibit anyone from using any other practices.

Any manufacturer marking equipment or materials in conformance with the marking requirements of an API standard is solely responsible for complying with all the applicable requirements of that standard. API does not represent, warrant, or guarantee that such products do in fact conform to the applicable API standard.

All rights reserved. No part of this work may be reproduced, stored in a retrieval system, or transmitted by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission from the publisher. Contact the Publisher, API Publishing Services, 1220 L Street, N.W., Washington, D.C. 20005.

FOREWORD

API publications may be used by anyone desiring to do so. Every effort has been made by the Institute to assure the accuracy and reliability of the data contained in them; however, the Institute makes no representation, warranty, or guarantee in connection with this publication and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use or for the violation of any federal, state, or municipal regulation with which this publication may conflict.

Suggested revisions are invited and should be submitted to the standardization manager, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005.

CONTENTS

	Page
CHAPTER 1 ROTOR REPAIR	1-1
CHAPTER 2 SPECIAL PURPOSE CENTRIFUGAL COMPRESSORS	2-1
CHAPTER 3 SPECIAL PURPOSE AXIAL COMPRESSORS	3-1
CHAPTER 4 SPECIAL PURPOSE STEAM TURBINES	4-1
CHAPTER 5 SPECIAL PURPOSE GEARS	5-1
CHAPTER 6 SPECIAL PURPOSE EXPANDERS	6-1
CHAPTER 7 POSITIVE DISPLACEMENT ROTARY SCREW TYPE COMPRESSORS	7-1

CHAPTER 1—ROTOR REPAIR

Currently in preview, click buy full version

CONTENTS CHAPTER 1

	Page
1 SCOPE/DEFINITION/REFERENCE STANDARDS	1-1
1.1 Scope	1-1
1.2 Alternative Procedures	1-1
1.3 Conflicting Requirements	1-1
1.4 Definition of Terms	1-1
1.5 Referenced Publications	1-2
1.6 Statutory Requirements	1-4
1.7 Unit Responsibility	1-4
2 PROCESS FOR OVERHAULING AND REFURBISHING A ROTOR	1-4
2.1 General	1-4
2.2 Typical Sequence of Events	1-4
2.3 Owner Supplied Information	1-5
2.4 Initial Scope of Inspection	1-5
2.5 Upgrade Alternatives	1-5
2.6 Developing the Scope of Repair	1-5
3 SELECTION OF A REPAIR SHOP	1-6
3.1 General	1-6
4 COMMUNICATION	1-6
4.1 General	1-6
4.2 Meetings	1-6
4.3 Electronic Drawing and Data Transmittal	1-6
4.4 Post-Shipment Review	1-6
5 TRANSPORT TO VENDOR'S SHOP	1-7
5.1 General	1-7
6 RECEIVING INSPECTION	1-7
6.1 Receiving of Rotor	1-7
6.2 Receiving inspection	1-7
7 INSPECTION OF ASSEMBLED ROTOR, PHASE I	1-7
7.1 General	1-7
7.2 Rotor Inspection	1-7
8 INSPECTION METHODS AND TESTING	1-9
8.1 General	1-9
8.2 Component Inspection	1-9
9 REPAIR PROCESSES AND NEW COMPONENT MANUFACTURE	1-11
9.1 General	1-11
9.2 Shaft Restoration	1-11
9.3 Coupling Shaft End	1-12
9.4 Thrust Collars	1-12
9.5 Shaft Sleeves and Spacers	1-12
9.6 Radial Runouts	1-12
9.7 New Component Manufacture	1-13

10	ROTOR ASSEMBLY AND BALANCING	1-13
10.1	General	1-13
10.2	Low Speed Component Balancing	1-13
10.3	Low Speed Assembly Balancing	1-14
10.4	Residual Unbalance Testing and Installation of Trim Parts	1-16
10.5	Balancing Equipment And Documentation	1-16
10.6	High Speed (At Speed) Balance	1-16
11	PREPARATION FOR SHIPMENT AND STORAGE	1-18
11.1	General	1-18
11.2	Containers	1-18
11.3	Rotor Supports	1-18
11.4	Packing	1-19
12	DOCUMENTATION	1-19
12.1	General	1-19
12.2	Proposals	1-19
12.3	Contract Data	1-19
12.4	Document Retention	1-19
APPENDIX A	PROCEDURE FOR DETERMINATION OF RESIDUAL UNBALANCE	1-21
APPENDIX B	NON-DESTRUCTIVE EXAMINATION METHODS	1-29
APPENDIX C	MAIN DRIVE COUPLINGS	1-37
APPENDIX D	RESTORATION METHODS (OVERVIEW)	1-49
APPENDIX E	FLUID FILM BEARINGS	1-55
APPENDIX F	TOTAL INDICATOR READING	1-63
APPENDIX G	VENDOR DATA DRAWING REQUIREMENTS (VDDR)	1-69
APPENDIX H	AUDITOR'S CHECK LIST	1-73
APPENDIX I	SELECTION OF A REPAIR SHOP CHECK LIST	1-85
APPENDIX J	SHIPPING CONTAINERS	1-105
APPENDIX K	QUALITY/MANUFACTURING PLAN	1-111
APPENDIX L	ANTI-FOULING/CORROSION RESISTANT/PERFORMANCE IMPROVEMENT COATINGS	1-127
APPENDIX M	EXAMPLES OF BEARING DAMAGE	1-133

Figures

1.A-1	(Blank) Residual Unbalance Work Sheet	1-23
1.A-2	(Blank) Residual Unbalance Polar Plot Work Sheet	1-24
1.A-3	Sample Residual Unbalance Work Sheet for Left Plane	1-25
1.A-4	Sample Residual Unbalance Polar Plot Work Sheet for Left Plane	1-26
1.A-5	Sample Residual Unbalance Work Sheet for Right Plane	1-27
1.A-6	Sample Residual Unbalance Polar Plot Work Sheet for Right Plane	1-28

1.B-1	Steps in Liquid Penetrant Inspection	1-30
1.B-2	Principles of Magnetic Particle Inspection	1-32
1.B-3	Equivalent Hardness Table.	1-35
1.C-1	Hub Dimensional Measurements.	1-41
1.C-2	Axial Pull-Up Tapered Coupling Hubs for 0.001 in. (I) per in. Diameter Interference	1-45
1.E-1	Preload Variations	1-57
1.E-2	Stack Height Check	1-59
1.F-1	Typical Horizontal Dial Test Indicator	1-63
1.F-2	Proper Positioning of Contact Stylus.	1-64
1.F-3	Inclination Error	1-64
1.F-4	Roundness Measurement.	1-65
1.J-1	Commercial Shipment Boxing	1-107
1.J-2	Steel Container	1-107
1.J-3	Commercial and Export Boxing, 905 Kg (2000 lbs) through 4530 Kg (1000 lbs)	1-108
1.J-4	Export Shipment Boxing, 4530 Kg (10,000 lbs) through 13,600 Kg (30,000 lbs)	1-108
1.J-5	Commercial and Export Boxing, 13,600 Kg (30,000 lbs) and Over	1-109
1.L-1	Coating to Resist Corrosion and Fouling Below 260°C (500°F)	1-128
1.L-2	Coating to Resist Corrosion and Fouling between 260°C (500°F) and 565°C (1050°F).	1-129
1.L-3	Aerodynamically Smooth Coating to Resist Corrosion and Fouling Up to 565°C (1050°F)	1-130
1.M-1a	Thrust Shoe Surface Abrasion	1-135
1.M-1b	Concentric Scoring of Thrust Pad	1-136
1.M-1c	Scoring of Pad	1-136
1.M-2a	Tin Oxide Damage	1-137
1.M-2b	Tin Oxide Damage	1-137
1.M-3a	Thermal Ratcheting	1-138
1.M-3b	Overheating/Oil Additives Plated Out	1-139
1.M-3c	Cracking and Fatigue at Joint	1-139
1.M-3d	Cracking of Pad Due to Operation at Excessively High Temperatures	1-140
1.M-3e	Cracking and Displacement of Pad Due to Overheating Under Steady Conditions	1-140
1.M-3f	Thermal Ratcheting Due to Thermal Cycling Through Excessive Temperature Range In Service.	1-141
1.M-4a	Stray Shaft Currents/Electrical Pitting (Frosting)	1-142
1.M-4b	Fine Hemispherical Pitting and Scoring of Bearing	1-143
1.M-4c	Stray Shaft Currents/Electrical Pitting (Frosting) Journal Bearing	1-144
1.M-5a	Edge Load Pivoted Shoe Showing Babbitt Mechanical Fatigue	1-145
1.M-5b	Edge Load Journal Shell with Babbitt Mechanical Fatigue	1-146
1.M-5c	Babbitt Fatigue in a Thin Thrust Plate.	1-147
1.M-5d	Babbitt Fatigue Cracking	1-148
1.M-5e	Babbitt Fatigue Cracking	1-149

1.M-6a	Thrust Shoe Cavitations Damage in Babbitt Face	1-150
1.M-6b	Thrust Shoe Cavitation Towards Outside Diameter	1-151
1.M-6c	Cavitation Damage on Outside Diameter of Collar	1-152
1.M-6d	Modification of Groove to Limit or Reduce Cavitation Damage	1-153
1.M-7a	Bearing Wiped Due to a Barreled Journal	1-154
1.M-7b	Uneven Wear of Bearing Due to Misalignment	1-155
1.M-8a	Compressor Bearing with Formation of "Black Scab"	1-156
1.M-8b	13% Cr. Journal Running in Bearing Shown in Figure 1.M-7a Showing Severe "Machining" Damage	1-157
1.M-8c	"Black Scab"—Wire Wooling—Formation on Thrust Pad	1-158

Tables

1.8-1	Generalized NDE Acceptance Criteria	1-10
1.C-1	Minimum Contact	1-42
1.D-1	Typical Properties of Various Thermal Spray Processes	1-51
1.E-1	Lift Check Correction Factor	1-59
1.L-1	Coating Application Summary	1-131
1.L-2	Relative Comparison of Coating Capabilities	1-132

Chapter 1—Rotor Repair

1 Scope/Definition/Reference Standards

1.1 SCOPE

1.1.1 This recommended practice covers the minimum requirements for the inspection and repair of special purpose rotating equipment rotors, bearings and couplings used in petroleum, chemical, and gas industry services.

This recommended practice is separated into 7 specific chapters. Chapters 2 through 7 are to be used separately from each other and in conjunction with Chapter 1. Refer to Chapter 1, Section 2 for the process used to overhaul and refurbish a rotor.

Tutorial Discussion: The document covers equipment manufactured to the requirements of API 612 Special Purpose Steam Turbines, API 613 Special Purpose Gears, API 617 Special Purpose Centrifugal Compressors, API 619 Special Purpose Rotary Positive Displacement Compressors, API 671 Special Purpose Couplings, and Hot Gas Expanders used in FCCU Power Recovery and Nitric Acid Services.

Note: A bullet (•) at the beginning of a paragraph indicates that either a decision is required or further information is to be provided by the owner. This information should be indicated on the appropriate data sheets; otherwise it should be stated in the quotation request or in the order.

1.1.2 The basis of repair recommendations shall be to return dimensions required for spare parts interchangeability to the latest design fits and clearances and produce a safe reliable rotating element capable of at least 5 years of uninterrupted operation.

Note: Returning these dimensions to the latest design fits and clearances will allow the repair to:

- Maintain interchangeability with other units.
- Use existing spare parts.
- Eliminate errors in manufacturing future parts that could be caused by undocumented dimensional changes.
- Maintain its critical speed margins and torque transmission capabilities.

Notes:

1. Small bearing clearance changes can move rotor critical speeds and changes in shrink fits can adversely affect rotor dynamics.

2. The latest design fits and clearances may not be as originally designed by the original equipment manufacturer (OEM), since rerates and/or upgrades may have been incorporated into the machine design.

1.1.3 Components manufactured for the repair shall be designed and constructed for a minimum service life of 20

years and at least 5 years of uninterrupted operation and in accordance with the latest API standards and Appendix K.

Use of previously manufactured components (surplus, etc.) and their acceptance criteria should be mutually agreed upon by all parties involved.

1.1.4 Unless otherwise specified, the repair shop (vendor) shall assume order responsibility.

1.2 ALTERNATIVE PROCEDURES

The vendor may offer alternative procedures and designs. (See Chapter 1, paragraph 2.5 for proposal requirements).

Note: Any exception to this recommended practice shall be clearly stated in the proposal as required in Chapter 1, paragraph 12.2.

1.3 CONFLICTING REQUIREMENTS

In case of conflict between this recommended practice and the inquiry, the inquiry shall govern. At the time of the order, the order shall govern.

1.4 DEFINITION OF TERMS

The terms used in this recommended practice are defined in 1.4.1 through 1.4.28.

1.4.1 almen strips: Metallic strips used to determine the intensity of peening.

1.4.2 calibration: The set of operations which establish, under specified conditions, the relationship between values indicated by a measuring instrument, or measuring system, or values represented by a material measure, and the corresponding known values of a standard.

Notes:

1. The results of calibration permit the estimation of indication errors of the measuring system, material measure or the assignment of values to marks on an arbitrary scale.

2. The results of calibration may be recorded in a document sometimes called a calibration certificate. Calibration method is a defined technical procedure for performing a calibration.

1.4.3 hydrodynamic bearings: Bearings that use the principles of hydrodynamic lubrication. The bearing surfaces are oriented so that relative motion forms an oil wedge, or wedges, to support the load without shaft-to-bearing contact.

1.4.4 indications: A response or evidence of a discontinuity that requires interpretations to determine its significance.

1.4.5 “J” strips: Thin rotating labyrinth strips held in position by caulking or prick punching to the shaft or sleeve to provide pressure breakdown. These may also be referred to as “L” strips or “T” strips.