Recommended Practice for Evaluation Procedures for Casing and Tubing Connections

API RECOMMENDED PRACTICE 5C5
SECOND EDITION, NOVEMBER 1996

American
Petroleum
Institute

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

Recommended Practice for Evaluation Procedures for Casing and Tubing Connections

Exploration and Production Department

API RECOMMENDED PRACTICE 5C5
SECOND EDITION, NOVEMBER 1996

American Petroleum Institute

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

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Generally, API standards are reviewed and revised, reaffirmed, or withdrawn at least every five years.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 date as an operative API standard or, where an extension has been granted, upon republication. Status of the publication can be ascertained from the API Authoring Department [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 director of the Authoring Department (shown on the title page of this document), 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 director.

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.

Copyright © 1996 American Petroleum Institute

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

FOREWORD

This recommended practice is under the jurisdiction of the API Committee on Standardization of Tubular Goods. This document is a test procedure that provides specific requirements to evaluate tubular connections for four classes. Within each class the procedures are slightly different for tubing than for casing. In addition, the tests required vary with size in some cases, and the test fluid changes with application. Accordingly, this document is not intended to be read consecutively from beginning to end.

Serious reviewers and users are strongly urged to read this recommended practice to determine the requirements for a specific application. A suggested procedure is to first consider reviewing the requirements for Class III casing. One should then consider Class III tubing followed by Class IV casing and tubing, Class II casing and tubing, and finally Class I casing and tubing.

Reviewing and using the recommended practice in this manner should make it much easier to understand and aid the reader in recognizing the layered concept. In addition, the intention to allow the manufacturer to first complete Class III testing and then advance to Class II and Class I without having to repeat all the tests is more readily apparent.

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 director of the Exploration and Production Department, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005.

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

CONTENTS

Page

1 SCOPE 1

2 REFERENCES 1
2.1 Standards 1
2.2 Other References 2

3 EVALUATION TESTING PROGRAMS 2

4 PROCEDURES FOR EVALUATION TESTS 2
4.1 Specimen Preparation 2
4.2 Makeup/Breakout Tests 5
4.3 Sealing Proof Tests 6
4.4 Failure Tests 9

5 GENERAL TEST REQUIREMENTS 10
5.1 Calibration Requirements 10
5.2 Rehearsal Tests 11
5.3 Material Property Tests 11
5.4 Makeup/Breakout Procedures 11
5.5 Leak Detection 13
5.6 Data Acquisition and Test Methods 14
5.7 Thermal Cycling Tests 14
5.8 Lubricant Pressure Monitoring During Thermal Soak 14

APPENDIX A—DETERMINATION OF TEST PRESSURE AND TEMPERATURE 53
APPENDIX B—DATA SHEETS 55
APPENDIX C—CONTENT GUIDELINE, CONNECTION EVALUATION SUMMARY REPORT 67
APPENDIX D—DETAILED REPORT TO API 69
APPENDIX E—EXAMPLE CALCULATIONS 71
APPENDIX F—FLOW CHART OF REQUIRED TESTS 89

Figures
1—Specimen Nomenclature 28
2—Connection Machining Requirements Coupled With Torque Shoulder and Metal and Resilient Seals 29
3—Connection Machining Requirements Integral With Torque Shoulder and Metal and Resilient Seals 30
4—Connection Machining Requirements Coupled With Torque Shoulder and Metal Seal but Without Resilient Seal 31
5—Connection Machinings Requirements Integral With Torque Shoulder and Metal Seal but Without Resilient Seal 32
6—Connection Machining Requirements Coupled With Torque Shoulder and Resilient Seal but Without Metal Seal 33
7—Connection Machining Requirements Integral With Torque Shoulder and Resilient Seal but Without Metal Seal 34
8—Connection Machining Requirements Coupled With Resilient Seal but Without Metal Seal and Torque Shoulder 35
9—Connection Machining Requirements Integral With Resilient Seal but Without Metal Seal and Torque Shoulder 36

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

Page
10—Connection Machining Requirements Coupled With Thread Seal Only and Without Torque Shoulder ... 37
11—Connection Machining Requirements Integral With Thread Seal Only and Without Torque Shoulder ... 38
12—Leak Observation Ports ... 39
13—Pin Crippling Grooves ... 39
14—Strain Gauge Locations for Tapered Connections With Thread Interference ... 40
15—Strain Gauge Locations for Two-Step Connections ... 41
16—Test 4.3.1 Initial Capped-End Pressure Cycling (at Room Temperature) ... 42
17—Test 4.3.2 Final Capped-End Pressure Cycling (at Room Temperature) ... 42
18—Test 4.3.3 Initial Capped-End Pressure Cycling With Thermal Cycling ... 43
19—Test 4.3.4 Final Capped-End Pressure Cycling With Thermal Cycling ... 44
20—Test 4.3.5 Compression/ID Pressure Load Limits ... 45
21—Test 4.3.5 Compression/OD Pressure Load Limits ... 45
22—Test 4.3.5 (Casing) Compression and Internal/External Pressure Cycling (at Room Temperature) ... 46
23—Test 4.3.5 (Tubing) Compression and Internal/External Pressure Cycling (at Room Temperature) ... 47
24—Tests 4.3.7 & 4.3.8 Tension/ID Pressure Load Limits ... 48
25—Test 4.3.7 Tension and Internal Pressure Cycling (at Room Temperature) ... 48
26—Test 4.3.8 Tension/OD Pressure Load Limits ... 48
27—Test 4.3.8 Tension and Internal/External Pressure Cycling (at Room Temperature) ... 49
28—Test 4.3.9 Strain Gauged Specimens With Internal Pressure and Tension and Compression ... 50
29—Example Stress Distribution Plot ... 50
30—Example Stress vs. Load Plot ... 51
31—Ring/Gland Port ... 51
32—Leak Trap Device ... 52
33—Leakage Measuring System ... 52
F-1—Casing ... 91
F-2—Tubing ... 93

Tables

1—Example Relationship Between Test Classes and Service Applications ... 15
2—Evaluation Testing for Connection Classifications I-IV ... 16
3—Class I—Casing Testing Sequence ... 18
4—Class I—Tubing Testing Sequence ... 18
5—Class II—Casing Testing Sequence ... 18
6—Class II—Tubing Testing Sequence ... 18
7—Class III—Casing Testing Sequence ... 18
8—Class III—Tubing Testing Sequence ... 18
9—Class IV—Casing Testing Sequence ... 19
10—Class IV—Tubing Testing Sequence ... 19
11—Responsibilities ... 19

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

Page

12—Example Stress and Strain Summary Table by Load Case 20
13—Example Stress and Strain Summary Table by Location 21
14—Example Format for Strain Gauge Data Makeup Data 22
15—Example Format for Strain Gauge Data Load Case Data...................................... 23
16—Periodic Load Frame Verification Summary 24
17—Determination of Internal Test Pressure for Various
Axial Loads and t/D's at 95 Percent of Yield Strength 25
18—Determination of Pj/Py for Various t/D's at Axial
Load of 80 Percent of Yield Load and Internal Pressure
for an Equivalent Stress of 90 Percent of Yield Stress 27

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

Recommended Practice for Evaluation Procedures for Casing and Tubing Connections

1 Scope

This document specifies tests to be performed to determine the galling tendency, sealing performance, and structural integrity of casing and tubing connections. It is intended that the words casing and tubing apply to the service application rather than to the diameter of the pipe. Connection evaluation by procedures other than testing is beyond the scope of this document. Interpolation and extrapolation of test results to connectors in other size, weight, grade, and materials is the responsibility of the user.

Example relationships between test classes and service application are suggested in Table 1. Other relationships may be more appropriate for individual users. Class I connections are intended for the most severe applications while Class IV connections are intended for the least severe applications. The types of tests and number of test specimens (indicated in Table 2) increase with the test class and service application. Class I tests include strain gauges on some specimens to enhance interpretation of connector performance. The failure tests for Class I and Class II connections are intended to provide data to determine quantitative estimates of connection structural reliability.

Tests on connections with multiple independent internal pressure seals shall include separate tests on two seals.

Supplementary tests may be appropriate for specific applications that are not evaluated by the tests herein. The user and manufacturer are encouraged to discuss well applications and limitations of the connection being considered.

Representatives of users or other third-party personnel are encouraged to monitor tests.

Quality control procedures for manufacture of test specimens shall be thoroughly documented consistent with procedures used for connections manufactured for well service and shall be retained in the Manufacturer's Detailed Test File.

Note: Items that are identified for inclusion in the Manufacturer's Detailed Test File shall not be included in any report provided to API.

The connection manufacturer shall certify that the connections manufactured for well service are of the same design and manufactured to the same dimensions and tolerances as those used in the evaluation tests.

Instructions in this document shall be followed. If adverse conditions not specifically addressed in these procedures are encountered, any resulting deviations to procedures shall be thoroughly documented in the summary report.

A manufacturer who completes tests in accordance with this document should submit a copy of the test results in the format specified in Appendix D to the API Production Department office. This copy shall be dated and reported test results certified by a management official of the reporting company. These reports, being public information, will be the subject of an annual report attached to the standardization conference agenda. The report will list all reports filed in the order received with the date received, test category (class and application), name of connection, drawing number, revision number (and date), pipe size, weight and grade, reporting company, and cost to order test report from API. A current list with additions since the last annual report will be maintained and supplied upon request. The report provided to API (as specified by Appendix D) will be maintained for at least 17 years after the date of receipt by API. Copies of the summary report (Appendix C) or full report (Appendix D) may be ordered from the API Production Department office.

API makes no warranty as to the accuracy or completeness of such reports. Questions regarding application of test results should be referred to the reporting company.

It shall be the responsibility of a manufacturing company that files a report to maintain copies of certified test results (documents required by Appendix D) and the Manufacturer's Detailed Test File. When test results have been reported to API, any subsequent change in the manufacturer's product specification shall be reported to API along with the new drawing number and revision level. The changes will be placed as an addendum to the original test report and presented separately in the annual API report under the category addendum.

When tests results are presented in verbal or written reports, articles, or advertisements and state that the tests were made in accordance with this document, such reports, articles, or advertisements shall not be worded to imply that the American Petroleum Institute either recommends or approves use of the subject connection(s).

2 References

2.1 STANDARDS

Unless otherwise specified, the most recent editions or revisions of the following standards, codes, and specifications shall, to the extent specified herein, form a part of this standard.

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

API

Bul 5C3	*Bulletin on Formulas and Calculations for Casing, Tubing, Drill Pipe, and Line Pipe Properties*
Spec 5L	*Specification for Line Pipe*

2.2 OTHER REFERENCES

The following references are also cited in text.

Applied Science Publishers[1]
Strain Gauge Technology

ASME[2]
90-Pet-25 *Application of Strain Space Plasticity Theory to Surface Gauge Measurements*

Measurements Group, Inc.[3]
Catalog 500, March 1996
Instruction Bulletins

Bulletin B-127	*Strain Gauge Installation With M-Bond 200 Adhesive*
Bulletin B-129	*Surface Preparation for Strain Gauge Bonding*
Bulletin B-130	*Strain Gauge Installation With M-Bond 43-B, 600 and 610 Adhesive Systems*
Tech Tips 609	*Strain Gauge Soldering Techniques*
Tech Tips 610	*Strain Gauge Clamping Techniques*

3 Evaluation Testing Programs

Each connection classification has an associated evaluation testing program. For these programs, a user test pressure and temperature shall be determined as specified in Appendix A. Tables 3–10 summarize the evaluation testing programs for Class I through Class IV. Evaluation testing procedures unique to each test are detailed in Section 4. However, general testing requirements common to several tests are described in Section 5 and referenced as required. Testing includes makeup/breakout tests, sealing proof tests, and failure tests. The tests are designed to determine the connection limitations relative to pipe body performance properties or previously known connection limitations (such as tension for a flush connection).

The specimens required for each test program are divided into letter sets (such as "Z," "Y"). All specimens in a letter set shall be made from common joints of pin and coupling materials. The specimens in each set shall be machined to the extremes of the manufacturer's tolerances and subjected to the same tests. The specimen sets listed in Tables 3–10 may be tested in any sequence; however, it is recommended that tests required for "Z" and "Y" be completed before attempting other tests.

Many groups and individuals need to cooperate to complete the evaluation tests. Responsibility for the various functions listed in Table 11 shall be established prior to initiating any tests. When used, the third-party witness serves as an independent observer to ensure that all tests are performed as specified by this document and that the results are accurately reported. Tests will normally be performed by a manufacturer to satisfy specific user requirements. However, testing by a single party is not prohibited. Testing details for the specific classes can be found as follows:

a. Class I—See Table 3 for casing and Table 4 for tubing.
b. Class II—See Table 5 for casing and Table 6 for tubing.
c. Class III—See Table 7 for casing and Table 8 for tubing.
d. Class IV—See Table 9 for casing and Table 10 for tubing.

4 Procedures for Evaluation Tests

This section specifies the procedures for the tests presented in Section 3. See Table 2 for a summary. Before testing begins, every load frame shall be calibrated as detailed in 5.1, and rehearsal tests shall be completed as detailed in 5.2. In addition, based on manufacturer test lab experience, measuring and recording instruments, such as pressure gauges and thermocouples, shall be calibrated periodically.

For each sealing proof test, specimens may be tested in series as a single assembly; however, for failure tests, each specimen shall be tested separately. For capped-end (no machine load) pressure testing, the axial load shall only be the result of the internal pressure acting on the end plugs. In all other combined load testing, the total axial load is the sum of the machine load plus any pressure-induced axial load.

All test procedures and test assemblies discussed in this section shall be consistent with general test requirements detailed in Section 5. All photographs specified by this document shall include identification of significant items shown in the photographs and included in the Detailed Report to API (see Appendix D).

4.1 SPECIMEN PREPARATION

4.1.1 Specimen Material Selection

Tables 3–10 show the number of specimens required for each specimen set. A specimen connects two pieces of pipe

[1]Applied Science Publishers, London, England and Englewood, New Jersey.

[2]American Society of Mechanical Engineers, 345 E. 47th Street, New York, New York 10017.

[3]Measurements Group Inc., P.O. Box 27777, Raleigh, North Carolina 27611.

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

(one collar and two pins for coupled connections, or one box and one pin for integral connections). Figure 1 presents information for a set of six specimens and the nomenclature to be used. The nomenclature is designed to identify each set of specimens, each specimen in the set, each pin and box, and each correct makeup configuration. For each individual specimen, each pipe length shall have an unsupported length L_p (Figure 1) and additional length for gripping and/or plugs.

In the case of integral connections, it is preferred that the connections be produced from upset tubulars. In this case, it is not necessary that the "A" and "B" end pup joints originate from a single mother joint. It is also acceptable to produce connections from stock having a machined external upset. In this case, the ID should only be bored if this is standard production practice. If this is not the case, the test connections shall be produced from stock having the correct ID for the weight of pipe evaluated.

The following applies for each set of test specimens:

a. The "A" end pup joints shall come from a single mother joint.

b. The "B" end pup joints shall come from a single mother joint (the "B" end pup joints are not required to come from the same mother joint as the "A" end pup joints).

c. Coupling material shall come from a single mother joint.

d. The material properties of each mother joint shall be determined as detailed in 5.3.

e. All material shall be in compliance with the appropriate API or proprietary material specification.

f. The total range of the average yield strength of all mother joints within a specimen set shall be less than or equal to 10 ksi.

g. The total range of measured yield strength at room temperature for each mother joint shall be less than or equal to 10 ksi.

h. The average coupling mother joint yield strength shall not exceed the minimum average pin mother joint yield strength by more than 5 ksi.

i. All appropriate data shall be recorded on the Material Property Data Sheet, B-2.

4.1.2 Specimen Machining

Before testing begins, the manufacturer's quality control and gauging procedures shall be documented. These procedures, and any others determined necessary, shall be used during fabrication of all test specimens.

To qualify the machine set up, a contour tracing (or equivalent such as an impression mold) is required from the pin nose (on pin) or lowermost shoulder (on box) up to two full threads at the beginning and end of a lot. A lot includes all products manufactured on a given machine during a continuous production cycle that is not interrupted by a wreck; for example, catastrophic tool failure or injurious machine malfunction (worn tools or minor tool breakage shall not be considered a wreck), tool holder change (except rough boring bar), or any other malfunction of either threading equipment or inspection gauges.

The contour tracings (minimum 20x magnification) shall be consistent with the appropriate machine drawing (dimension and profile). The piece representing the start of the lot shall be verified prior to machining the test specimens. The contour tracings shall be a part of the Manufacturer's Detailed Test File.

Specific interferences and ring groove fill are required for the test specimens. The specimens shall be machined as specified by the appropriate figure. (See Figures 2–11.)

It is intended that the thread interference adjacent to the seal be at the extremes indicated by the appropriate figure. Accordingly, the influence of the thread taper must be allowed for by any one or a combination of the following: the connection design, the gauging practice, or the taper and thread pitch diameters selected for the test pieces.

When the tests require only three specimens, they shall be machined consistent with the requirements for specimens 1, 2, and 3. Machining of thread and seal interferences will be at the extreme dimensions of manufacturer's specifications for maximum and minimum interferences (minimum and maximum clearances). Therefore, each pin and box will be machined at the extremes of their respective diametrical dimensions.

For the specimen set "X" of Class I tubing (only) the diametrical dimension of the metal seal shall be machined ten percent within the tolerance range specified by the manufacturer on the pin or box drawing and any amount outside the tolerance range. For example, if the connection is required to have L-(minimum) seal interference and the box has a metal seal diameter of 2.400 inches ± 0.003 inch, then the box metal seal diameter must be no smaller than 2.4024 inches [i.e., 2.400 inches ± 0.003 inch - (0.003 inch x 2 / 10)]. The box may be any amount larger (at the manufacturer's option) than the standard drawing maximum, which would be 2.403 inches for this example. The same requirements would be placed on the pin metal seal diameter so that it could be no more than 0.0006 inch larger than the smallest diameter allowed by the manufacturer's drawing. If the tolerance was ±0.001 inch, then the metal seal diameter could be no more than 0.0002 inch within the tolerance. This close tolerance machining is only required for the metal seal dimensions. For those connections that do not have a metal seal, this requirement is not applicable. When the metal seal diameters are specified as an absolute diameter and the location is toleranced to vary axially, then the specimens shall be machined with close tolerances on the axial location to achieve the same result as when the diameter is specified at a precise axial position as illustrated above.

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

For all other dimensions specified by Figures 2–11 (all Classes and all specimen sets), the deviation from the extremes shall not be more than 0.001 inch within tolerance. However, each pin and each coupling may be out of tolerance, and the manufacturer has the responsibility to determine the amount that each pin and box may be out of tolerance. To achieve H-(maximum) interference, the pin dimensions shall be no lower than 0.001 inch below, but any amount above the maximum diametrical design dimensions of the pin; the coupling shall be no higher than 0.001 inch above, but any amount below the minimum diametrical design dimensions of the coupling. To achieve L-(minimum) interference, the pin dimensions shall be no higher than 0.001 inch above, but any amount below the minimum diametrical design dimensions of the pin; the coupling dimensions shall be no lower than 0.001 inch below, but any amount above the maximum diametrical design dimensions of the box. For example, for a minimum interference connection with a box tolerance range of 3.301–3.304 inch, 3.303 inch or greater is acceptable. For a pin tolerance range of 3.311–3.314 inch, 3.312 inch or smaller is acceptable. This would result in an interference of 0.009 inch or less for the assembly.

To achieve maximum ring groove fill, the following tolerance extremes are required:

a. Ring groove minimum distance from box face (or end of pin as applicable).
b. Minimum groove width.
c. Minimum groove diameter.
d. Maximum ring width.
e. Maximum ring thickness.

To achieve minimum ring groove fill, the opposite tolerance extremes shall be used. In addition, any other parameters that affect the ring groove fill shall be documented in the Specimen Preparation section of the Connection Evaluation Summary (Appendix C).

In addition, connections machined as specified in Figures 8 and 9 shall also have the box pitch diameter machined to achieve the seal ring fill specified (that is, the maximum box pitch diameter is required when high seal ring fill is specified, and the minimum box pitch diameter is required when the low seal ring fill is specified). There is no requirement for the pin pitch diameter.

The selected surface treatment of each pin and box shall be consistent with the surface treatment applied to production components.

Specimen set "Y" need not be ported since those specimens are used only for simple tension tests. On connections with multiple seals, only the two innermost seals shall be tested for internal pressure. All other potential seals are considered extraneous for these tests and shall be bypassed either by porting between seals or by crippling seals. To ensure that the appropriate seal is being tested, porting is required (see 5.5). Specimens shall be ported as follows:

a. As shown in Figure 12, drill a front port and a rear port in connections having two separate seals. For Class II specimens used in 4.4.5, having two internal pressure seals, the front port may be replaced with a drilled hole as shown in Figure 12.
b. For connections with only a metal seal, drill only the front port (placed behind the seal).
c. For connections with abutting seals, resilient seals in the threads, or only threads, drill only the rear port (placed behind the seal). See 5.5.
d. The front port shall be installed after the first make/break of 4.2.1, and the rear port shall be installed after the final makeup of 4.2.1.
e. Porting shall be in compliance with 5.5.

All extraneous seals, such as multiple metal or resilient seals and torque shoulders that cannot be bypassed with porting, shall be crippled as shown in Figure 13 and detailed in 5.5. If an extraneous seal does not prevent test pressure from reaching the appropriate seal, it shall not be crippled.

If a specimen is damaged before testing is completed, a replacement specimen is required. This specimen shall be machined and assembled to the same tolerances (Figures 2–11) as the failed specimen, and all testing required for the original specimen shall be repeated. Replacement and/or remachined connections shall be identified with an "R1" after the "A" and "B" identification the first time they are reworked, "R2" the second time they are reworked, and so forth.

All proprietary data that is to be reported on the right-hand table of the Specimen Geometry Data Sheet, B-3, shall be given as a percent of tolerance range of the measured dimension (0 percent represents the minimum value of the measured dimension, and 100 percent represents the maximum value).

Note: 50 percent does not necessarily represent the nominal value. One exception to the above is the reporting of connection ovality, which shall be reported as a real number.

Manufacturers who gauge their product by a method other than the traditional ring and plug gauge shall identify and report their gauging method(s) in Appendix C, Connection Evaluation Summary Report, and shall report the results of the gauging in the applicable space on Data Sheet B-3.

4.1.3 Installation of Strain Gauges

The use of strain gauges applies to Class I casing and tubing. Two specimens of coupled designs (three connections) shall be strain gauged, and three specimens (three connections) of integral designs shall be strain gauged. The

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

specimens to be strain gauged are identified in Figures 2–5 and apply to connections 1A, 1B, and 3A for coupled designs and connections 1, 3, and 4 for integral designs. Connections without metal-to-metal seals are not typically used in Class I applications. Therefore, strain gauges are not shown in Figures 6–11.

Specimens shall be instrumented (or gauged) with electrical resistance strain gauges. At least 20 strain gauge rosettes shall be used on each connection (where a connection is defined as one pin and one box). Figure 14 shows locations to be gauged for a single step tapered connection. At least five rosettes shall be used on the pin at 0 degree, and five rosettes on the box at 0 degree, and five rosettes at 180 degrees for both pin and box. Figure 15 shows gauge locations for a two-step connection. Some connection designs will not contain all the features shown in Figures 14 and 15, while others may contain more features than those shown. For example, if a resilient seal is not used, then rosette 3 shall be centered between rosettes 2 and 4 and rosette 8 centered between 7 and 9. All specific features shall be gauged at locations on the connection that have the most structural response and significance. The two pipe bodies of each specimen shall be gauged with four rosettes per body as shown in Figures 14 and 15.

Each strain gauge rosette shall consist of two strain gauges oriented 90 degrees to each other. One gauge shall be aligned in the circumferential direction and the other in the axial direction. The overall grid dimensions of each strain gauge shall be ⅛ inch x ⅛ inch. Micro-measurements rosette type CEA-06-125UT 350 (see Catalog 400 in 2.2) is an example of the desired size and type rosette.

Installation of the rosettes shall be done with care. Recognized industry procedures and techniques for surface preparation, bonding, soldering, and coating shall be used, such as the "Tech Tip" published by the Measurements Group (see 2.2). Selection of an adhesive shall be done with consideration of the pressure load on the inside of the pin member (examples of acceptable adhesives are Measurements Group M-Bond 200 and M-Bond 610, see 2.2). Pressure acting on the face of a gauge may cause debonding of the gauge, and therefore a strong bonding adhesive shall be used. Pits and voids in the adhesive may cause excessively high measured strains when subjected to pressure. Strain gauge rosettes, adhesives, and coatings shall be rated by the manufacturer for a minimum of 3 percent strain.

Electrical feed throughs shall be used to bring the pin strain gauge leadwires out of the specimen. Care shall be used in the selection and installation of the feed throughs with regard to electrical resistance (so as to not be excessive), pressure capability, and method of attachment to the specimen.

The pressure medium used for strain gauge tests shall be a highly nonconducting liquid, such as transformer oil, or gauges shall be adequately waterproofed so that water can be used. Filler bars are not recommended because of the problem of entanglement with the strain gauge lead wires.

Instrumentation used to measure and record performance shall be a data acquisition system made for strain gauge applications. The system shall have a resolution of at least ±10 microstrain, a range of at least ±15,000 microstrain, and accuracy of at least ±1 percent at strain levels between 1000 and 5000 microstrain. The "3-wire hook-up" method shall be used to connect each strain gauge to the instrumentation, according to *Strain Gauge Technology*. Allowances for leadwire resistance shall be made in the measured strains. (Some data acquisition systems do this automatically.)

Stresses up to the yield strength of the specimen shall be calculated from the measured strains using triaxial stress field equations, as follows:

$$S_a = \frac{E}{1-u^2}[ea + u \times ec] - P\frac{(u)}{1-u}$$

$$S_c = \frac{E}{1-u^2}[ec + u \times ea] - P\frac{(u)}{1-u}$$

$$S_r = -P$$

Where:

S_a = Calculated axial stress from measured strains.
S_c = Calculated circumferential stress from measured strains.
S_r = Radial stress.
E = Elastic modulus of material.
u = Poisson's ratio.
ea = Measured axial strains.
ec = Measured circumferential strains.
P = Pressure acting on face of gauge (pin gauges only).

For stress above the specimen yield strength, the above equations do not apply since the elastic limit is exceeded and strains become nonlinear. Stress above yield shall be calculated from the measured strains according to the procedure in *Application of Strain Space Plasticity Theory to Surface Strain Gauge Measurements*, or axial and circumferential measured strains shall be plotted.

4.2 MAKEUP/BREAKOUT TESTS

4.2.1 Initial Makeup/Breakout (Tubing and Casing)

The following procedures apply to the initial makeup/breakout tests:

a. Review 5.4 for general makeup/breakout procedures.

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

b. Make up the assemblies as shown on the appropriate figure (see Figure 2–11) to the maximum recommended torque.
c. Break out within 60 minutes and examine specimens. Record connection geometry data on Data Sheet B-3.
d. Make up the "A" pin in the "B" box and the "B" pin in the "A" box to the maximum recommended torque. For integral connections, make up the No. 1 pin in the No. 2 box, the No. 2 pin in the No. 3 box, and so forth.
e. Break out after 24 hours minimum and examine specimens. Install the front port as shown in Figure 12 and as discussed in 5.5. Cripple the torque shoulder as discussed in 5.5.2.a.
f. Make up in the configuration of b. to the torque as specified on the appropriate figure (see Figures 2–11) for the specimen. Record the stabilized dope pressure. Monitoring for stabilized dope pressure may continue for 24 hours or may be terminated when the rate of change is 5 percent or less in 30 minutes.
g. Install the rear port into the threads as shown in Figure 12 and discussed in 5.5.
h. Report results on Data Sheet B-4—Specimen Makeup/Breakout Data Sheet and on Data Sheet B-3—Specimen Geometry Data Sheet as specified in 4.1.2 and 5.4.

Note: The above porting sequence is recommended to minimize galling concerns. It is acceptable to machine the ports at an earlier time and install plugs until such a time as the ports are required for monitoring purposes.

4.2.2 Final Makeup/Breakout (Tubing Only)

The following procedures apply to the final makeup/breakout tests for tubing only:

a. Review 5.4 for general makeup/breakout procedures.
b. For Classes I, II, and III, break out and examine the No. 6 specimen. If severe galling is experienced, do not break out the remaining specimens, but proceed to 4.3.4. If galling is not a problem on specimen No. 6, then proceed to break out specimens Nos. 5 and 4. If both specimens Nos. 5 and 4 exhibit severe galling, then do not break out the remaining specimens (Nos.1, 2, and 3), reassemble specimen No. 6 to the specified torque and proceed to 4.3.4. If only specimens No. 5 or No. 4 exhibit severe galling, continue breaking out specimens Nos. 1, 2, and 3 and proceed to step c. Severe galling is defined as galling that cannot be field dressed suitable for use in a well.

For Class IV, break out and examine the No. 3 specimen. If severe galling is experienced, do not break out the remaining specimens, but proceed to 4.3.2. If galling is not a problem on specimen No. 3, then proceed to break out specimens Nos. 2 and 1.
c. Record connection geometry data on Data Sheet B-3.
d. Each connection will be made up and broken out six times. The connections shall be clean and dry, and the quantity of thread compound applied during the first and last assembly of each connection shall be recorded. The peak trapped lubricant pressure shall be recorded (stabilization of dope pressure not required). It is acceptable, but not necessary, to clean the connection members and record the quantity of thread compound on other subsequent assemblies. Make up the specimens to the maximum torque recommended by the manufacturer and break out. On make up Nos. 1, 3, and 5, make up the "A" pin into the "A" box and the "B" pin into the "B" box. On makeup Nos. 2, 4, and 6 make up the "A" pin into the "B" box and the "B" pin into the "A" box. In the case of integral connections, the No. 1 pin shall be assembled with boxes number 2, 3, 4, 5, 6, and 2, in that order. The number 2 pin shall be assembled with the number 3, 4, 5, 6, 1, and 3 boxes, and an analogous procedure shall be followed for pin numbers 3, 4, 5, and 6.
e. Break out and examine specimens. Record connection geometry data on Data Sheet B-3.
f. Make up the assemblies as specified on the appropriate figure (Figures 2–11) for the specimen. Record the stabilized dope pressure 4.2.1.f.
g. Report results on Data Sheet B-4—Specimen Makeup/Breakout Data Sheet and on Data Sheet B-3—Specimen Geometry Data Sheet as specified in 4.1.2 and 5.4.

4.2.3 Strain Gauged Specimens Makeup

The following procedures shall be followed for all specimens requiring strain gauges:

a. Apply strain gauges per 4.1.3.
b. Place specimen in the makeup frame and apply handtight torque (approximately 50 feet-pounds).

Zero/balance or otherwise prepare the data acquisition system and strain gauges for testing; record initial strain gauge values.
c. Attach makeup tongs and makeup the specimen to the specified torque. Couplings shall be floated-on (torque shall be applied to one of the pipe ends and resisted by the other pipe end without touching the coupling). Attachment of makeup and backup tongs should be at least two pipe diameters away from the closest strain gauge.
d. Release the grip (or completely remove the tongs, if possible), wait 60 seconds, and record all strain gauge values. Record strain gauge values every 15 minutes for one hour. Continue to record strain gauge readings until the change in reading deviates less than 10 percent or 10 micro-inches in a 15-minute period.
e. Remove the specimen from the makeup frame and report strain gauge values per 4.3.9.

Refer to 5.4 for general makeup procedures.

4.3 SEALING PROOF TESTS

Use dry nitrogen as the pressure medium in proof tests for all production casing for Classes I, II, and III and for all tubing. Use water or oil for all external pressure tests, all production casing tests for Class IV, and for all protective (intermediate) and surface casing tests. The specified test

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

STD.API/PETRO RP 5C5-ENGL 1996 ■ 0732290 0561970 401 ■

pressures and axial loads for the combined load tests may need to be adjusted downward as specified in Appendix A consistent with connection limitations determined in the capped-end pressure tests and simple tension tests to failure. For connections with very low tensile efficiency, procedures to minimize axial loading may be appropriate. All adjustments in loads shall be reported. Use Data Sheet B-7 to calculate and report the required test loads.

In addition to the data required herein, the manufacturer shall record and report other data the manufacturer knows to be pertinent. If a leak occurs during the cycling before the values of axial load and/or pressure of a hold period are reached, stop and hold the load and pressure constant for 15 minutes, then continue the test. Testing shall not be discontinued because of minor leakage. Report the data for these hold periods on Data Sheet B-8—Sealing Proof Test Data Sheet and on Data Sheet B-5—Sealing Proof Test Data Sheet. If the connection does not have a rear seal, has abutting front and rear seals, or has only threads, the pressure cycling that tests the rear seal shall be omitted from all sealing proof tests. Use Data Sheet B-8 to record leakage during the tests.

4.3.1 Initial Capped-End Pressure Cycling Tests (Tubing Class IV)

Follow these procedures for initial capped-end pressure cycling tests for Class IV tubing:

a. Determine user pressure as specified in Appendix A, Equation A-1.
b. Perform the test according to instructions in 5.5 and 5.6 as shown in Figure 16. Complete pressure cycles F1–F5.
c. Report results on Data Sheet B-8—Sealing Proof Test Data Sheet and on Data Sheet B-5—Sealing Proof Test Data Sheet.

4.3.2 Final Capped-End Pressure Cycling Tests (Tubing and Casing, Class IV)

Follow these procedures for final capped-end pressure cycling tests:

a. Determine user pressure as specified in Appendix A, Equation A-1.
b. Determine the maximum pressure as specified in Appendix A, Equation A-4.
c. Perform the test according to instructions in 5.5 and 5.6 and as shown in Figure 17.
d. Report results on Data Sheet B-8 and on Data Sheet B-5.

Pressure	Connection Temperature	Load Steps
User	Room	F1–F5
Maximum	Room	F6–F10

4.3.3 Initial Capped-End Pressure Cycling With Thermal Cycling Tests (Tubing)

Follow these procedures for initial capped-end pressure cycling with thermal cycling tests:

a. Determine user pressure as specified in Appendix A, Equation A-1.
b. Determine user temperature as specified in Appendix A, Equation A-2.
c. Perform the test according to instructions in 5.5 and 5.6, and as shown in Figure 18.

Seal	Pressure	Connection Temperature	Load Steps
Front	User	Room	FP1
All	None	User	FP2
Front	User	User	FP3
Front	User	Room	F1–F5
Front	User	User	F6–F10
Front	User	Room	F11–F15
Rear	User	Room	R1–R5
Rear	User	User	R6–R10
Rear	User	Room	R11–R15

d. Report results on Data Sheet B-8—Sealing Proof Test Data Sheet and on Data Sheet B-5—Sealing Proof Test Data Sheet.

4.3.4 Final Capped-End Pressure Cycling With Thermal Cycling Tests (Tubing and Casing)

Follow these procedures for final capped-end pressure cycling with thermal cycling tests:

a. Determine user pressure as specified in Appendix A, Equation A-1.
b. Determine user temperature as specified in Appendix A, Equation A-2.
c. Determine the maximum pressure as specified in Appendix A, Equation A-4.

Seal	Pressure	Connection Temperature	Load Steps
Front	User	Room	FP1
All	None	User	FP2
Front	User	User	FP3
Front	User	Room	F1–F5
Front	User	User	F6–F10
Front	User	Room	F11–F15
Front	Maximum	Room	F16–F20
Front	Maximum	User	F21–F25
Front	Maximum	Room	F26–F30
Rear	User	Room	R1–R5
Rear	User	User	R6–R10
Rear	User	Room	R11–R15
Rear	Maximum	Room	R16–R20
Rear	Maximum	User	R21–R25
Rear	Maximum	Room	R26–R30

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

d. Perform the test according to instructions in 5.5 and 5.6, and as shown in Figure 19.
e. Report results on Data Sheet B-8—Sealing Proof Test Data Sheet and on Data Sheet B-5—Sealing Proof Test Data Sheet.

4.3.5 Compression and Internal/External Pressure Cycling Tests (Tubing and Casing ≤ 7⅝ Inches OD)

Follow these procedures for compression and internal/external pressure cycling tests:

a. Heat specimens for 24 hours at user temperature, then cool the specimens.
b. Determine the internal pressure for the load hold points shown in Figure 20 as specified in Appendix A, Equation A-5.
c. Determine the external pressure for the load hold points shown in Figure 21 as specified in Appendix A, Equation A-6.
d. Determine the axial load for the hold point using Appendix A, Equation A-3.
e. Perform the test according to instructions in 5.5 and 5.6, and as follows:

Casing—See Figure 22

Seal	Pressure	Load Steps
Front	Internal	F1–F23
Rear	Internal	R1–R23
Series	External	S1–S23

Tubing—See Figure 23

Seal	Pressure	Load Steps
Front	Internal	F1–F23
Series	External	S1–S23
Front	Internal	F24–F46
Rear	Internal	R1–R23

f. Report results on Data Sheet B-8—Sealing Proof Test Data Sheet and on Data Sheet B-5—Sealing Proof Test Data Sheet.

4.3.6 Thermal Cycling Tests With Tension and Internal Pressure (Class I Tubing Only)

Follow these procedures for tension and internal pressure cycling tests for Class I tubing only:

a. Determine the axial load and internal pressure as specified in Appendix A, Equations A-7and A-8.
b. Apply the axial load specified by Equation A-7.
c. Apply the internal pressure specified by Equation A-8 while reducing the machine load to compensate for any pressure-induced loads.
d. Apply ten thermal cycles according to the instructions in 5.7. During the thermal cycles, the machine load and the internal pressure shall be adjusted to maintain the axial load and pressure determined in a.
e. Release the internal pressure and cycle the axial load ten times between zero and the axial load determined in Equation A-7.
f. Reapply the axial load and internal pressure as specified in b. and c. above.
g. Apply 15 thermal cycles according to the instructions in 5.7. For these thermal cycles, it is acceptable to allow the internal pressure and axial load to fluctuate with temperature. The maximum pressure and total axial load in each cycle shall equal the load and internal pressure determined in a.
h. Report results on Data Sheet B-8—Sealing Proof Test Data Sheet and on Data Sheet B-5—Sealing Proof Test Data Sheet.

4.3.7 Tension and Internal Pressure Cycling Tests (Casing Only)

Follow these procedures for tension and internal pressure cycling tests for casing only:

a. Heat specimens for 24 hours at user temperature, then cool the specimens.
b. Determine the internal pressure for the load hold points shown in Figure 24 as specified in Appendix A, Equation A-5.
c. Perform the test according to instructions in 5.5 and 5.6, and as shown in Figure 25.

Seal	Load Steps
Front	F1–F25
Rear	R1–R25

d. Report results on Data Sheet B-8—Sealing Proof Test Data Sheet and on Data Sheet B-5—Sealing Proof Test Data Sheet.

4.3.8 Tension and Internal/External Pressure Cycling Tests (Tubing Only)

Follow these procedures for tension and internal/external pressure cycling tests for tubing only:

a. Heat specimens for 24 hours at user temperature, then cool the specimens. This step may be omitted if the specimens have been thermal cycled in prior tests.
b. Determine the internal pressure for the load points shown in Figure 24 as specified in Appendix A, Equation A-5.
c. Determine the external pressure for the load hold points shown in Figure 26 as specified in Appendix A, Equation A-6.

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

d. Perform the test according to instructions in 5.5 and 5.6, and as shown in Figure 27.

Seal	Pressure	Load Steps
Front	Internal	F1–F25
Series	External	S1–S25
Front	Internal	F26–F50
Rear	Internal	R1–R25

e. Report results on Data Sheet B-8—Sealing Proof Test Data Sheet and on Data Sheet B-5—Sealing Proof Test Data Sheet.

4.3.9 Strain Gauge Specimens With Internal Pressure and Tension/Compression

The specimens shall be loaded to seven load cases, as shown in Figure 28, consisting of tension, compression, and internal pressure and following the 95 percent yield von Mises ellipse. Use Equation A-5 in Appendix A to determine maximum loads in each load case. At least ten equal load increments shall be used to reach each load case, and strain data shall be recorded at each increment. Strains shall also be recorded at the beginning and end of each load case at zero load. The application of the loads shall be as shown in Figure 28 so as not to inadvertently overload the sample. For specimens with strengths less than the pipe, test loads will have to be reduced accordingly per Appendix A. Loading sequence shall be in numerical order according to load case (1 through 7), with load cases shown in Figure 28 and described below:

1. Capped-end pressure (with tension load on cap).
2. Tension only.
3. Pressure only.
4. Tension to 90 percent yield followed with pressure.
5. Compression only.
6. Compression to 50 percent yield followed with pressure.
7. Same as Load Point 1.

If, during the testing, loss of some strain gauges is experienced, then the test shall be stopped and all inoperative rosettes replaced for any of the following conditions:

a. For the box and pipe outside the rosettes— loss of any two adjacent rosettes, loss of both the 0° and 180° rosettes at a location (for example, box critical section), or loss of four or more rosettes.
b. For the pin inside the rosettes—loss of both the 0° and 180° rosettes at either the critical section or the metal seal.

More than two rosettes may be used at these locations and testing continued as long as any one rosette remains operative. Loss of a rosette is defined as the loss of either of the two gauges in a rosette by lack of stability, unexplainable high strains, or loss of circuit. It should be noted that strains from a de-bonded gauge may have a linear negative response with pressure and may be difficult to identify.

Data reduction and reporting shall be in five forms, as follows:

a. Tabulated strains and stresses for each rosette as given in Table 12. A total of 15 tables shall be provided—one for makeup at the end of the required hold time and one at maximum load and one at removal of all load for the seven load cases shown in Figure 28.
b. Tabulated stresses and strains for three locations on the connection plus the pin pipe body connection locations, which are the pin critical section, box critical section, and pin internal primary seal. Tabulated values shall be the average of the 0° and 180° rosettes at locations on the connection and the average of all four rosettes on the pipe. Reported data shall be for makeup at the end of the required hold time plus maximum load and removal of the load for all seven loadcases, as shown in Table 13.
c. Stress distribution plots as shown in Figure 29. A total of six sheets per connection shall be provided—axial, circumferential, and von Mises plots for both the pin and box, using average stresses at each rosette location (average of 0° and 180° rosettes). For coupled specimens, both connections shall be plotted on the same sheet. Scale size shall be at least 6 inches for the abscissa and 4 inches for the ordinate.
d. Stress versus load plots as shown in Figure 30. A total of 28 sheets per connection shall be provided. Scale size shall be at least 6 inches for the abscissa and 4 inches for the ordinate.

The average stresses and strains (average of 0° and 180° rosettes) for the pin critical section, box critical section, and pin internal primary seal shall be plotted. The pin pipe body average stresses (average of all four rosettes) shall be plotted. Plots of the connection rosettes shall start with the makeup stresses at zero load.
e. All measured strains and calculated stresses on a floppy disk in the format shown in Tables 14 and 15 and in ASCII format. The disks shall be in Microsoft® MS-DOS® Version 2.0 or higher for IBM® or 100 percent compatible computers and 5 ¼ inches [130mm] double sided, high density, double track TPI. The data shall be in a LOTUS 1-2-3® or EXCEL® spreadsheet or compatible format. Makeup data and each of the seven load cases shall be recorded as separate files.

4.4 FAILURE TESTS

Scribe specimens to allow measuring of pipe length L_G (see Data Sheet B-6—Failure Test Data Sheet) before and after tests. Test the specimens individually, not in series. For failure tests with internal pressure, apply water or oil pressure to both the specimen ID and the front port if the specimen has both a front and rear seal. If the specimen has a single seal, apply pressure only to the specimen ID.

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

In a test with internal pressure, if a continuous leak occurs before structural failure, declare failure and terminate the test.

Structural or leakage failure at the end fixtures that grip the specimen invalidates the test, and the test shall be repeated unless the specimen is at imminent failure as indicated by gross deformation or other documentation indicating the maximum load has been achieved. If the specimen is undamaged by failure of an end fixture, reuse the specimen and repeat the test. However, if the specimen is damaged by the failure of an end fixture, repeat the test with a new specimen. The new specimen shall be machined to the same tolerances as specified in 4.1.2 and will undergo the same tests as the damaged specimen it is replacing.

Note: IBM® is a registered trademark of International Business Machines Corporation. LOTUS 1-2-3® is a registered trademark of Lotus Development Corporation. Microsoft®, MS-DOS®, Multiplan®, EXCEL®, and the Microsoft logo are registered trademarks of the Microsoft Corporation. Compression to Failure Tests (Class IV Casing)

4.4.1 Compression to Failure Tests (Class IV Casing)

Follow these procedures for compression to failure tests for Class IV casing:

a. Perform the test only on casing with a specified outer diameter (*OD*) greater than 8 percent inches.
b. The test specimens shall have an unsupported pipe body length on each end of *D* plus 6 times the square root of *Dt* from the load mechanism to the transition to the connector. (See Figure 1.)
c. Load the specimens until they fail in compression in accordance with 5.6. Stop the test when failure occurs due to buckling, fracture, thread jump-in, or severe bulging. Determine failure by either a drop in the test load or observations of the specimen geometry.
d. Report the results of each test on a separate Failure Test Data Sheet B-6.

4.4.2 Capped-End Pressure to Failure Tests

Follow these procedures for capped-end pressure to failure tests:

a. Apply pressure in the specimens until failure occurs under capped-end conditions according to instructions in 5.5 and 5.6.
b. Report the results of each test on a separate Failure Test Data Sheet B-6.

4.4.3 Tension to Failure Tests

Follow these procedures for tension to failure tests:

a. Load the specimens until they fail in tension according to the instructions in 5.6.
b. Report the results of each test on a separate Failure Test Data Sheet B-6.

4.4.4 Low Pressure With Tension Increasing to Failure Tests

Follow these procedures for low pressure with tension increasing to failure tests:

a. Heat specimens 4, 5, and 6 for 24 hours at user temperature, then cool the specimens.
b. Perform the test according to instructions in 5.5 and 5.6.
c. Apply internal pressure to 60 percent of the pressure given by Equation A-4.
d. Maintain constant pressure and increase the tension until the specimen fails.
e. Report the results of each test on a separate Failure Test Data Sheet B-6.

4.4.5 High Pressure With Tension Increasing to Failure Tests

Follow these procedures for high pressure with tension increasing to failure tests:

a. Heat the specimens for 24 hours at user temperature, then cool the specimens.
b. Test the specimens in accordance with 5.5 and 5.6.
c. Apply internal pressure equal to 100 percent of the pressure given by Equation A-4.
d. Maintain constant pressure and increase the tension to specimen failure.
e. Report the results of each test on a separate Failure Test Data Sheet B-6.

5 General Test Requirements

5.1 CALIBRATION REQUIREMENTS

Calibration test reports for the load frame, temperature, pressure, and torque measuring devices shall be retained in the Manufacturer's Detailed Test File for possible future reference; however, documentation of other calibrations is not required.

Equipment calibration at any time during a test program may be appropriate based on the required test loads and past equipment usage.

The minimum frame calibration load (5.1.1) shall not be greater than 50 percent of the yield load of the connection or pipe being evaluated.

5.1.1 Annual Load Frame Calibration

Each load frame used in a tension, compression, or combined loading test shall be calibrated at least annually with device(s) (such as load cells) traceable to the National Institute of Standards and Technology (NIST). The calibration should consist of two passes of a minimum of ten equal increments ranging from the minimum calibration load to the maximum calibration load (defined as the "loading range"). The

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

minimum calibration load is defined as the lowest load (usually 10 percent of the maximum load) that the frame will reliably calibrate within ±1.0 percent error. The error, E, and the percent error, E_p, are calculated as follows:

$$E = \text{(Indicated load - actual load)}$$
$$E_p = E/\text{actual load} \times 100$$

The percent error for all loads within the loading range of the frame shall not exceed ±1.0 percent. The calibration results shall be provided (for both passes) in a table similar to the following example.

Assume that a 2 million pound frame is calibrated from 200,000 pounds to 2 million pounds. The following table depicts the average of the two passes:

Indicated Load	Actual Load	Error	Percent Error
203,000	200,000	3,000	1.50
400,500	400,000	500	0.63
599,000	600,000	-1,000	-0.17
797,500	800,000	-2,500	-0.32
999,500	1,000,000	-500	0.05
1,201,500	1,200,000	1,500	0.12
1,404,000	1,400,000	4,000	0.28
1,606,000	1,600,000	6,000	0.38
1,797,000	1,800,000	-3,000	-0.16
1,991,000	2,000,000	-9,000	-0.45

5.1.2 Periodic Load Frame Verification

A calibration bar shall be instrumented with 12 OD biaxial strain gauge rosettes such as those shown on the Calibration Data Sheet B-1. The bar shall be calibrated immediately after calibration of the load frame (5.1.1). In the event that the load frame is subjected to unusual loads, such as applying a load beyond the calibration range or a high pressure gas failure of a sample being axially loaded in the frame, the bar shall be used to verify the load frame calibration. Apply the test load in accordance with the requirements in 5.6 using at least five equal load increments. Record the data on Data Sheet B-1 (or equivalent for the strain gauge data sheet) and Table 16.

An alternate to the periodic calibration bar is the certified calibration bar that is used to perform the annual calibration required in 5.1.1. This certified bar shall be NIST traceable.

5.1.3 Pressure Transducer Calibrations

Each internal pressure transducer used in a combined loading test shall be calibrated at least annually. Recalibration at any time during the test program may be appropriate based on past equipment usage. The percent error for pressures within the loading range should not exceed ±0.5.

5.2 REHEARSAL TESTS

Rehearsal tests are recommended for the first evaluation test program performed at each test facility. Each test procedure should be rehearsed. Perform each rehearsal test using the same type specimens, test programs, test procedures, and test reports that are specified for the actual connection tests.

5.3 MATERIAL PROPERTY TESTS

Perform three room temperature tensile tests on coupons from each mother joint of casing, tubing, and coupling stock used in the test program. Cut one test coupon from each end of the mother joint and one test coupon from near the middle of each mother joint. Report the material property data required on Data Sheet B-2.

Perform one elevated temperature tensile test (at the user temperature) of a coupon from the middle of each mother joint used for specimen set "Z" for Classes I, II, and III and also for specimen set "X" for Class I tubing. For each elevated temperature test, report the actual coupon temperature by monitoring a thermocouple attached to the coupon. Report the test data on the same Material Property Data Sheet B-2 used for the room temperature test.

Stress-strain or load-strain tests plot from zero strain to 3 percent strain only. For all plots, use graph paper with 1 × 1 inch or 1 × 1 cm major divisions, and with 5, 10, or 20 subdivisions per inch or cm. The full graph scale shall occupy 5–20 graph inches of the graph paper.

Tensile test coupons shall be longitudinal. Either a strip coupon (preferred) or the largest practical American Society for Testing and Materials round coupon shall be used. The yield strength as specified by API for the grade tested shall be considered the "official" yield strength. However, the 0.2 percent offset yield strength shall be reported for information. A sketch of the test coupon shall be shown on Data Sheet B-2. For connections machined on line pipe, tensile test coupons shall be per API Specification 5L.

5.4 MAKEUP/BREAKOUT PROCEDURES

The manufacturer shall specify the maximum and minimum quantity of thread compound that may be applied to the connection as well as the areas to which the compound is to be applied. For preference, the maximum and minimum quantities shall be specified as weights. Alternatively, the manufacturer shall provide photographs and detailed descriptions of the way in which thread compound is to be applied. If the performance of the connection is not dependent on the quantity of thread compound applied, this should be stated.

The connections that are to be assembled to the maximum recommended torque (Figures 2–11) shall have the maximum recommended quantity of thread compound applied while the connections that are to be assembled to the minimum recommended torque shall have the minimum recommended quantity of thread compound applied.

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

STD.API/PETRO RP 5C5-ENGL 1996 ■ 0732290 0561975 T93 ■

For each makeup, clean the connection completely and weigh the amount of lubricant applied to each connection. Make up all specimens using API high pressure modified thread compound unless the manufacturer specifically recommends use of an alternate lubricant for both tests and field applications. The manufacturer may use an alternate lubricant for connection assemblies only if the manufacturer reports the reason for the recommendations, the type (brand) of lubricant, and the chemical composition of the lubricant. Use the same lubricant for all test specimens. The seal ring size used shall be as specified for the box member of the specimen regardless of which pin is being made up.

The makeup torques specified in 4.2.1 and 4.2.2 and in Figures 2–11 are the maximum and minimum torques recommended by the manufacturer. For a high specified torque, the maximum or greater torque is acceptable. For a low specified torque, the minimum or lower torque is acceptable. If actual makeup torque is between minimum and maximum recommended torque, then the connection shall be broken out and retorqued. The manufacturer shall specify the rpm range for makeup. All connections shall be made up at the maximum recommended rpm.

Monitor and record makeup and breakout torques on torque vs. turn plots; turn resolution shall be 1/100 turn or better. All torque vs. makeup position plots shall be saved until all testing is completed. Torque vs. makeup position plots for the first and last makeup of 4.2.1 and 4.2.2 and for any additional makeups associated with connections exhibiting abnormal behavior such as galling and leakage, shall be included in the detailed report to API (refer to Appendix D).

Specimens shall be made up using the tongs available in the field (USA); vertical makeup is preferred. For coupled connections, floating is prohibited for test specimens (each side shall be made up separately) except for strain gauged specimens, which are required to be floated on. Photograph all makeup equipment and at least one connection being made up.

During makeup, the front port of all sealing-proof specimens with both front and rear seals shall be monitored for lubricant pressure buildup during the last makeup of 4.2.1 and the first and last makeups of 4.2.2. Monitor the pressure using a transducer attached to the front port. Before makeup, fill the transducers and transducer pressure lines completely with lubricant to assure accurate and immediate pressure measurement. Verify that pressure lines are full by obtaining a pressure reading with minimal stroking of a hand pump.

If the transducer on any specimen records 500 psi or greater, the connection is considered to be trapping lubricant. In this case, the stabilized trapped lubricant pressure observed on a specimen shall be reapplied to the front port of the specimen during thermal soaking, as specified in 5.8, and during proof testing with internal pressure (unless the pressure bleeds off). Apply the lubricant pressure, and monitor leakage using the same transducer system used for monitoring lubricant pressure (see 5.5).

Following each breakout, pins and boxes may be refurbished using only the technique recommended by the manufacturer for field use.

Monitor each connection for galling. If possible, feel each connection after makeup to determine if the temperature is abnormally high. Inspect the specimens carefully following each breakout. Evaluate the torque vs. makeup position plots for correlation with galling or other unusual occurrences. Annotate each plot to indicate the test specimen, pin-end, makeup number, and observations at the time of makeup.

Measure pin and box metal seal ovality and report measurements on Data Sheet B-3 in units of inches. Ovality is defined as maximum seal diameter minus minimum seal diameter.

Tests shall be documented by thoroughly photographing pertinent areas as follows:

a. Connections 1ZA and 2ZA after the initial surface treatment has been applied.
b. Connections 1ZA and 2ZA after doping.
c. Connections 1ZA and 2ZA after the first makeup/breakout of 4.2.1, before cleaning and after cleaning.
d. On any connection where galling is observed, photograph all damage before and after cleaning, and after field dressing.

Seal ring data that is to be reported on Data Sheet B-4 shall be given as a percent of tolerance range of the measured dimensions, that is 0 percent represents the minimum value of the measured dimension and 100 percent represents the maximum value.

Note: 50 percent does not necessarily represent the nominal value.

If the connection does not use a seal ring, record N/A (not applicable) in the appropriate space on Data Sheet B-4.

The following special provisions are applicable only for strain gauged specimens:

Strain gauged specimens shall be made up one time only. Making continuous torque-turns plots on strain gauged couplings may require the use of a special fixture. If this fixture is available, torque-turns plots shall be provided as for all other connections. If a fixture is not available, the testing agency shall have the option of reporting total turns for each end of the connection. This can be done by marking each end of the pipe and coupling at the reference torque position and measuring total turns upon final makeup. Using this method, the number of full turns (each time the marks pass one another) shall be visually noted for each end. Partial turns shall be determined by measuring the distance between reference marks (±1/32 in along the contour using a tape) and converting to turns using the following formula:

Partial turns = (measured distance between marks, inches)/[3.142 (nominal pipe diameter, inches)].

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

5.5 LEAK DETECTION

5.5.1 Porting Connections

A single metal (or other) seal connection whose threads are not sealing elements need not be ported. Leak ports between multiple seals shall be installed as required by connection design to permit independent evaluation of each seal. However, violating the integrity of the connection by drilling ports or crippling seals may compromise the test results for some users, necessitating the preparation and testing of additional specimens.

On connections with multiple seals, only the two innermost seals shall be tested for internal pressure. All other potential seals are considered extraneous for the tests and shall be bypassed by either porting between seals or by crippling seals.

During thermal cycle testing, if nitrogen gas is used as the pressure medium, it is recommended that a tracer gas such as argon be used in addition. A sensor calibrated to detect such gas should be used to verify that any bubbles detected are coming from the pressure medium and not from the thread compound degassing or from thermo-expansion in the connection.

If the connection traps lubricant during makeup, use pressure transducers to monitor sealing performance. Apply the stabilized trapped lubricant pressure to the transducer lines before starting each sealing proof test. If the connection does not trap lubricant, use one of the leakage monitoring alternatives.

To test the rear seal during application of internal pressure, monitor the rear port and tee the front seal leak port into the internal pressure source line. Apply pressure to both the ID and the front seal port simultaneously.

For all sealing proof tests to which external pressure is applied, plug the front port (if two ports exist) and leave the rear port open. (Therefore, if the connection has two seals, both seals will be tested in series.) Apply pressure to the OD of the specimen over both the box and the pins. (The rear port will be pressurized in this manner.) Monitor leaking using the line used to apply internal pressure.

During all failure tests in which internal pressure is applied to specimens having front and rear ports, the internal pressure must also be applied to the front port. For the combined loading failure test in 4.4.5 the front port can be replaced by a $\frac{1}{16}$-inch hole (minimum) as depicted in Figure 12. The internal pressure will automatically be applied through this optional $\frac{1}{16}$-inch hole. Monitor the rear port for leakage.

5.5.2 Leak Collection Methods

The methods to be used for leak collection are described as follows in 5.5.2.1–5.5.2.3.

5.5.2.1 Crippling Procedures

All extraneous seals, such as multiple metal or resilient seals and torque shoulders that cannot be bypassed with porting, shall be crippled as shown in Figure 13. To cripple a torque shoulder, two $\frac{1}{64}$-inch deep by $\frac{1}{64}$-inch wide grooves (minimum) of any shape shall be cut (filed and so forth) into the torque shoulder face.

Extraneous metal seal or resilient seal trap surfaces (other than threads) shall be crippled by cutting two $\frac{1}{64}$-inch deep by $\frac{1}{64}$-inch wide grooves of any shape into the radial metal surfaces of the pins or boxes. All crippling grooves shall be deburred. If an extraneous seal does not prevent test pressure from reaching the appropriate seal, it shall not be crippled.

5.5.2.2 Porting Procedures

For porting, drill both front and rear ports (see Figure 12) into the box unless the connection has abutting front and rear seals or has only front seals, has only a resilient seal in the threads, or has only threads. In the case of only front seals, drill only front ports. In the case of abutting seals, resilient seals in the threads, or only threads, drill only rear ports. Place the front port between the front seal and the first thread. Place the rear port in the sealing thread length approximately three threads behind the rear seal. Drill the rear ports as flat bottom holes with diameters greater than one thread pitch and extending below the root of the pin thread.

Each front port shall use a conical metal-to-metal seal fitting (such as Autoclave or equivalent) with either a ring gland (see Figure 31) or integral to the box (see Figure 12). Each rear port may use a drilled hole with NPT threads or other low-pressure fitting.

5.5.2.3 Collared Leak Trap Device

The collared leak trap device consists of an O-ring held against the face or OD of the box by a ported collar. The collar is sealed against the pipe body by another O-ring, and the entire assembly is held in place by set screws or tiebolts spanning the connection apparatus (see Figure 32).

Note: Autoclave Engineers—Erie, Pennsylvania

5.5.3 Leakage Measurement Methods

All leak monitoring lines shall be blown out periodically to prevent plugging. At a minimum, the lines shall be blown out prior to starting a test and after the first thermal cycle. Leakage shall be monitored by one of the following methods:

5.5.3.1 Immersion Tank Method

The immersion tank method requires that the connection be totally covered with liquid and allow visual observation of any bubbles escaping a pressurized specimen. Video cameras lend themselves nicely to the observation task as they provide a permanent record of metered leakage and can be operated from a safe location remote from the pressurized sample. Since an immersion tank is not quantitative, it is only acceptable for Class IV connections.

5.5.3.2 Inverted Graduated Cylinder System

Another leakage monitoring system is as illustrated in Figure 33. Here the specimen leak collection line is

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

inserted under an inverted graduated cylinder that has been filled with water and placed in a pan of water. Any leakage displaces the water providing a direct reading of bubbles per minute or volume per unit time (cc/hr).

5.5.4 Alternate Leak Collection and Measurement Systems

Alternate leak collection and measuring systems that can be shown to meet the intent of these tests and have minimal effect on structural behavior are not prohibited.

5.6 DATA ACQUISITION AND TEST METHODS

Reduce the stored energy of the test pressure media by inserting filler bars inside the specimens during all tests with internal pressure except for strain gauged specimens.

For tension tests, four biaxial strain gauge rosettes shall be placed on one pipe body, at a common cross section, remote from the test connector and the grip mechanism to monitor bending. The strain gauges are to be equally spaced (90 degrees apart) around the circumference with one gauge aligned with the axis of the pipe. In general, pipe bending stress shall be less than about 15 percent of the membrane tension stress when loading is above 50 percent of test specimen yield strength.

To monitor the internal or external pressure that is applied to a specimen, connect a pressure transducer to the internal or external pressure cavity of the specimen. Locate the pressure transducer near the specimen and not at the source of the pressure.

In all failure tests, try to avoid reduction in the load and pressure. In combined loading failure tests, do not allow the pressure to deviate by more than ±10 percent from the target pressure during tensile loading to failure.

For all tests, record the pressures, axial load, and temperature continuously vs. time using strip charts approximately 8 inches wide to allow space for annotation and resolution. This data shall be retained in the Manufacturer's Detailed Test File. In all cases, the scale selected shall be consistent with the major divisions on the graph paper. The chart speed shall be at least 2 inches per hour.

Graph the pressure in sealing proof tests using a full scale pressure range from zero to P_y specified in Appendix A, Equation A-4. Graph the pressure in failure tests using a full scale pressure range of 2 times P_y. Graph the machine load in sealing proof tests using a full scale load range from zero to T_y specified in Appendix A, Equation A-3. Graph the machine load in failure tests using a full scale load range of 1.5 times T_y.

For all graphs of temperature vs. time, use the user temperature plus at least 50°F for the full temperature scale. For all tests. use graph paper with 1 × 1 inch or 1 × 1 cm major divisions and with 5, 10, or 20 subdivisions per major division.

Load each specimen at an *axial stress rate of 15 ksi/min* or less. Pressurize each specimen at a *pressure rate of 5 ksi/min or less*. These rates are specified to ensure that accurate sealing and structural performance data are recorded in the tests. Loading and pressurizing the specimen may be performed continuously or intermittently. However, in the case of intermittent loading and pressurizing, the rates between load and pressure increments shall not exceed the stipulated rates. There is no limit on the maximum or minimum rate for removing pressure or axial loads. In elevated temperature tests, maintain test temperature not less than the user temperature.

For each failure test, photograph the specimen after failure and show the location and mode of failure.

5.7 THERMAL CYCLING TESTS

A thermal cycling is a change from cold to hot to cold. A minimum time of five minutes shall elapse at or above the maximum temperature and five minutes at or below the minimum temperature selected. The maximum temperature shall not be less than the user temperature. A minimum of 50 hours shall elapse between the first and last thermal cycle. The temperature changes for the thermal cycling tests may be produced by any means capable of producing sufficiently large temperature variations throughout the couplings of the test specimens. The method chosen must be demonstrated capable of producing a temperature change of at least 180°F at the opposite side of the connection to that at which the temperature change is applied. In the case of induction heating, this temperature change shall be produced at the opposite side of the connection to the induction coils. These temperatures shall be monitored during testing using thermo-couples using the same method or procedures demonstrated acceptable (see above). In the case of induction heating, appropriate steps shall be taken to ensure that the temperature measured is not affected by local temperature variations in the vicinity of the thermo-couple and that the temperature measured is representative of that of the coupling. Alternatively, it shall be shown by other means that a sufficiently large temperature change is taking place. Provided a temperature change of at least 180°F is produced throughout the whole of the coupling, it is not necessary for thermal equilibrium to be attained.

5.8 LUBRICANT PRESSURE MONITORING DURING THERMAL SOAK

If the connection traps over 500 psi stabilized trapped lubricant pressure during makeup, then reapply the pressure before starting the thermal soak. Record the lubricant pressure during the thermal soak and subsequent cooling. If the connection pressure at the end of the thermal soak/cool is above 500 psi, then this pressure shall be reapplied at the beginning of all subsequent test procedures (see 4.3.3 through 4.3.8).

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

STD.API/PETRO RP 5C5-ENGL 1996 ■ 0732290 0561978 7T2 ■

Table 1—Example Relationship Between Test Classes and Service Applications

	Connector Test Classes					
	Production Tubulars Service Severity			Drilling Tubulars Service Severity		
Differential Working Pressure	High	Normal	Low	High	Normal	Low
Over 12,000 psi	I	I	II	I	II	III
8,000-12,000 psi	I	II	III	II	II	III
4,000-8,000 psi	II	III	III	III	III	IV
0-4,000 psi	III	IV	IV	IV	IV	IV

Note: The values quoted for differential working pressure are intended for guidance only. It may be necessary to apply criteria other than differential working pressure such as risk, severity of service, and environmental considerations to select the class of tests appropriate for a particular application.

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

Table 2—Evaluation Testing for Connection Classifications I-IV

Procedure		Class I		Class II		Class III		Class IV	
No.	Description	CSG	TBG	CSG	TBG	CSG	TBG	CSG	TBG
	Specimen Preparation								
4.1.1	Specimen material selection	27	27	24	24	12	12	3	3
4.1.2	Specimen machining	27	27	24	24	12	12	3	3
4.1.3	Installation of strain gauges	2	2	—	—	—	—	—	—
	Makeup/breakout Tests								
4.2.1	Initial makeup/breakout	27	27	24	24	12	12	3	3
4.2.2	Final makeup/breakout	—	6	—	6	—	6	—	3
4.2.3	Strain gauged specimens makeup	2	2	—	—	—	—	—	—
	Sealing Proof Tests								
4.3.1	Initial capped-end pressure cycling at ambient temperature	—	—	—	—	—	—	—	3
4.3.2	Final capped-end pressure cycling at ambient temperature	—	—	—	—	—	—	3	3
4.3.3	Initial capped-end pressure cycling with thermal cycling	—	6	—	6	—	6	—	—
4.3.4	Final capped-end pressure cycling with thermal cycling	6	6	6	6	6	6	—	—
4.3.5	Compression and internal/external pressure cycling	3	3	—	—	—	—	—	—
4.3.6	Thermal cycling tests with tension and internal pressure	—	6	—	—	—	—	—	—
4.3.7	Tension and internal pressure cycling	6	—	3	—	—	—	—	—
4.3.8	Tension and internal/external pressure cycling	—	6	—	3	—	—	—	—
4.3.9	Strain gauged specimens with int. pressure and tension/compression	2	2	—	—	—	—	—	—
	Failure Tests								
4.4.1	Compression to failure	—	—	—	—	—	—	3	—
4.4.2	Capped-end pressure to failure	6	6	6	6	6	6	—	—
4.4.3	Tension to failure	6	6	6	6	6	6	—	—
4.4.4	Low pressure increasing tension to failure	6	6	6	6	—	—	—	—
4.4.5	High pressure increasing tension to failure	6	6	6	6	—	—	—	—
4.4.4	Total Test Specimens Required: (Accounting for prior use of specimens)	27	27	24	24	12	12	3	3

Note: CSG = casing; TBG = tubing

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

This page is intended to be removed for use with Tables 3 through 10.

Test Procedure No.
Cross Reference

Procedure	
No.	Description
	Specimen Preparation
4.1.1	Specimen Material Selection
4.1.2	Specimen Machining
4.1.3	Installation of Strain Gauges
	Makeup/Breakout Tests
4.2.1	Initial Makeup/Breakout
4.2.2	Final Makeup/Breakout
4.2.3	Strain Gauged Specimens Makeup
	Sealing Proof Tests
4.3.1	Initial Capped-End Pressure Cycling Tests at Ambient Temperature
4.3.2	Final Capped-End Pressure Cycling Tests at Ambient Temperature
4.3.3	Initial Capped-End Pressure Cycling With Thermal Cycling Tests
4.3.4	Final Capped-End Pressure Cycling With Thermal Cycling Tests
4.3.5	Compression and Internal/ External Pressure Cycling Tests
4.3.6	Thermal Cycling Tests With Tension and Internal Pressure
4.3.7	Tension and Internal Pressure Cycling Tests
4.3.8	Tension and Internal/External Pressure Cycling Tests
4.3.9	Strain Gauge Specimens With Internal Pressure and Tension/Compression
	Failure Tests
4.4.1	Compression to Failure Tests
4.4.2	Capped-End Pressure to Failure Tests
4.4.4	Low Pressure With Tension Increasing to Failure Tests
4.4.5	High Pressure With Tension Increasing to Failure Tests

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

STD.API/PETRO RP 5C5-ENGL 1996 ■ 0732290 0561981 297 ■

Table 3—Class I—Casing Testing Sequence

Specimen set	= Z	Y	X	W	V[b]	Total
(No. of specimens)	= 6	6	6	6	3	27
Testing Sequence	Procedure Number[a]					
1	4.1.1	4.1.1	4.1.1	4.1.1	4.1.1	
2	4.1.2	4.1.2	4.1.2	4.1.2	4.1.2	
3	4.2.1	4.2.1	4.2.1	4.1.3	4.2.1	
4	4.3.4	4.4.3	4.3.7	4.2.3	4.3.5	
5	4.4.2		4.4.4	4.3.9		
6				4.2.1		
7				4.4.5		

[a]As defined in Table 2.
[b]Applied only to Casing less than or equal to 7 5/8 inches that is machined to tolerances specified for specimens 1, 2, and 3.

Table 4—Class I—Tubing Testing Sequence

Specimen set	= Z	Y	X	W	V[b]	Total
(No. of specimens)	= 6	6	6	6	3	27
Testing Sequence	Procedure Number[a]					
1	4.1.1	4.1.1	4.1.1	4.1.1	4.1.1	
2	4.1.2	4.1.2	4.1.2	4.1.2	4.1.2	
3	4.2.1	4.2.1	4.2.1	4.1.3	4.2.1	
4	4.3.3	4.4.3	4.3.6	4.2.3	4.3.6	
5	4.2.2		4.3.8	4.3.9		
6	4.3.4		4.4.4	4.2.1		
7	4.4.2			4.4.5		

[a]As defined in Table 2.
[b]Specimens machined to tolerances specified for specimens 1, 2, and 3.

Table 5—Class II—Casing Testing Sequence

Specimen set	= Z	Y	X	W	Total
(No. of specimens)	= 6	6	6	6	24
Testing Sequence	Procedure Number[a]				
1	4.1.1	4.1.1	4.1.1	4.1.1	
2	4.1.2	4.1.2	4.1.2	4.1.2	
3	4.2.1	4.2.1	4.2.1	4.2.1	
4	4.3.4	4.4.3	4.3.7[b]	4.4.5	
5	4.4.2		4.4.4		

[a]As defined in Table 2.
[b]Only specimens 1, 2, and 3 to be used for sealing proof tests.

Table 6—Class II—Tubing Testing Sequence

Specimen set	= Z	Y	X	W	Total
(No. of specimens)	= 6	6	6	6	24
Testing Sequence	Procedure Number[a]				
1	4.1.1	4.1.1	4.1.1	4.1.1	
2	4.1.2	4.1.2	4.1.2	4.1.2	
3	4.2.1	4.2.1	4.2.1	4.2.1	
4	4.3.3	4.4.3	4.3.8[b]	4.4.5	
5	4.2.2		4.4.4		
6	4.3.4				
7	4.4.2				

[a]As defined in Table 2.
[b]Only specimens 1, 2, and 3 to be used for sealing proof tests.

Table 7—Class III—Casing Testing Sequence

Specimen set	=	Z	Y	Total
(No. of specimens)	=	6	6	12
Testing Sequence		Procedure Number[a]		
1		4.1.1	4.1.1	
2		4.1.2	4.1.2	
3		4.2.1	4.2.1	
4		4.3.3	4.4.3	
5		4.4.2		

[a]As defined in Table 2.

Table 8—Class III—Tubing Testing Sequence

Specimen set	=	Z	Y	Total
(No. of specimens)	=	6	6	12
Testing Sequence		Procedure Number[a]		
1		4.1.1	4.1.1	
2		4.1.2	4.1.2	
3		4.2.1	4.2.1	
4		4.3.3	4.4.3	
5		4.4.2		
6		4.3.4		
7		4.4.2		

[a]As defined in Table 2.

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

Table 9—Class IV—Casing Testing Sequence

Specimen set	=	Z	Total
(No. of specimens)	=	3[b]	3
Testing Sequence		Procedure Number[a]	
1		4.1.1	
2		4.1.2	
3		4.2.1	
4		4.3.2	
5		4.4.1[c]	

[a]As defined in Table 2.
[b]Specimens machined to tolerance specified for specimens 1, 2, and 3.
[c]Required only for casing with a specified outer diameter greater than 8x.

Table 10—Class IV—Tubing Testing Sequence

Specimen set	=	Z	Total
(No. of specimens)	=	3[b]	3
Testing Sequence		Procedure Number[a]	
1		4.1.1	
2		4.1.2	
3		4.2.1	
4		4.3.1	
5		4.2.2	
6		4.3.2	

[a]As defined in Table 2.
[b]Specimens machined to tolerance specified for specimens 1, 2, and 3.

Table 11—Responsibilities

Item	User	3rd Pty. Witness	Manuf.	Tester
1. Select class, connection, and "user" temperature and maximum shut-in pressure	1	—	2	—
2. Review mechanical design, analysis, and existing test data	1	—	2	—
3. Review and affirm manufacturer's quality control procedures	1	—	2	—
4. Review drawings and establish specified tolerance limit, review contour tracing overlay, porting and crippling	1	—	1	—
5. Determine third party participants	1	—	2	—
6. Review test procedures as a group	1	1	1	1
7. Select test material	2	1	1	—
8. Manufacture specimens	2	1	1	—
9. Perform calibration and rehearsal tests	2	1	—	1
10. Review calibration and rehearsal test results	1	1	2	2
11. Conduct required tests	2	1	2	1
12. Verify tests conducted consistent with procedures	—	1	1	—
13. Record test results	—	—	—	1
14. Verify test results	—	1	—	—
15. Prepare total data package	—	—	1	1
16. Verify total data package	—	1	—	—
17. Review test results and recommend structural, sealing, and other limitations	—	—	1	—
18. Review test results and recommendations and establish structural sealing and other limitations	1	—	—	—

Note: A "1" indicates primary responsibility for the item. A "2" indicates a support function. Where more than one "1" or "2" is shown, the responsibility is shared as required. Note that the Third Party Witness (when used) is a witness function only.

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

Table 12—Example Stress and Strain Summary Table by Load Case

Specimen: ______________________ Load case: ______________________

Date: ______________________ Load values: ______________________

		Microstrain		Stress (psi)		
Scan	Rosette	Axial	Circum.	Axial	Circum.	Von Mises
	1					
	2					
	3					
	4					
	5					
	6					
	7					
	8					
	9					
	10					
	11					
	12					
	13					
	14					
	15					
	16					
	17					
	18					
	19					
	20					
	21					
	22					
	23					
	24					
	25					

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

Table 13—Example Stress and Strain Summary Table by Location

Specimen: ______________________ Date: ______________________

Location[a]	Load Case	Average Strain		Average Stress	
		Axial	Circum.	Axial	Circum. Von Mises
	Makeup				
	1 Max				
	1 Zero				
	2 Max				
	2 Zero				
	3 Max				
	3 Zero				
	4 Max				
	4 Zero				
	5 Max				
	5 Zero				
	6 Max				
	6 Zero				
	7 Max				
	7 Zero				

Note: [a]Total of four tables per connection: pin critical (gauge 6), box critical (gauge 4), pin seal (gauge 10), and pipe body.

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

Table 14—Example Format for Strain Gauge Data Makeup Data

File name:	xxxxxxxx
Product name:	xxxxxxxx
Manufacturer's name:	xxxxxxxx
Testing service name:	xxxxxxxx
Test engineer:	xxxxxxxx
Test sample name:	A-1C-B
Date of test:	MAR 18 '87 - 2:41:56 PM

Test Sample Information	Pin A	Pin B	Coupling
Identification	A	B	1C
Outside diameter, inch	7.625	7.601	8.503
Inside diameter, inch	6.012	6.036	6.259
Yield stress, psi	93400	93400	98000
Ultimate strength, psi	110000	110000	115000
Length, inch	48	47	12
Number of rosettes	14	14	20
Rosette orientation	Hoop-axial	Hoop-axial	Hoop-axial
Other			
Load case #:	Make up		
Beginning scan #:	1		
Ending scan #:	2		

Strain Gauge Results

Scan #: 1
Torque: 0 ft-lbs
Time: MAR 18 '87 - 2:41:56 PM

Scan #	Ros #	e1	e2	S1	S2	S EQ
1	A1	0	1	9	32	29
1	A2	0	0	0	0	0

Note: Continue for all rosettes. Use "A" and "B" in the rosettes identification to indicate the end of the collar.

Scan #: 2
Torque: 15000 ft-lbs
Time: MAR 18 '87 - 3:11:55 PM

Scan #	Ros #	e1	e2	S1	S2	S EQ
2	A1	5	32	498	1113	966
2	A2	3	-17	-59	-515	488

Note: Continue for all rosettes. Use "A" and "B" in the rosettes identification to indicate the end of the collar.

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

Table 15—Example Format for Strain Gauge Data Load Case Data

File Name:	xxxxxxxx
Product Name:	xxxxxxxx
Manufacturer's Name:	xxxxxxxx
Testing Service Name:	xxxxxxxx
Test Engineer: x	xxxxxxxx
Test Sample Name:	A-1C-B
Date Of Test:	MAR 18 '87–2:41:56 PM
Load Case #:	1
Beginning Scan #:	1
Ending Scan #:	10

Table of Loads

Scan #	Load Units	Tension kips	Compression kips	Internal Pressure psi	External Pressure psi	Time
1	0 kips	0	0	0	0	MAR 18 '87 - 2:41:56 PM
2	500 kips	500	0	0	0	MAR 18 '87 - 3:11:55 PM
3	1000 kips	1000	0	0	0	MAR 18 '87 - 2:13:51 PM
4	0 psi	1000	0	0	0	MAR 18 '87 - 3:39:59 PM
5	6000 psi	1000	0	6000	0	MAR 18 '87 - 3:43:23 PM
6	8000 psi	1000	0	8000	0	MAR 18 '87 - 3:48:20 PM
7	10000 psi	1000	0	10000	0	MAR 18 '87 - 3:41:06 PM
8	12000 psi	1000	0	12000	0	MAR 18 '87 - 3:57:20 PM
9	0 psi	1000	0	0	0	MAR 18 '87 - 3:58:20 PM
10	0 kips	0	0	0	0	MAR 18 '87 - 3:59:20 PM

Strain Gauge Results

Scan#:	1
Load:	0 kips
Tension:	0
Compression:	0
Internal Pressure:	0
External Pressure:	0
Other:	
Time:	MAR 18 '87 - 2:41:56 PM

Scan #	Ros#	e1	e2	S1	S2	S EQ
1	A1	01	1	9	32	29
1	A2	00	0	0	0	0

— Continue for all rosettes. Use "A" and "B" in the rosette identification to indicate the end of the connection.
— Repeat the above for each *scan* for each step and for each of the seven load cases as illustrated in Figure 28 for Test 4.3.9.

Scan #: 2
Load: 500 kips

— Continue for all rosettes. Use "A" and "B" in the rosette identification to indicate the end of the connection.
— Repeat the above for each *scan* for each step and for each of the seven load cases as illustrated in Figure 28 for Test 4.3.9.

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

Table 16—Periodic Load Frame Verification Summary

Date: ______________________ Maximum Test Load: ______________________

		Calculated	Load @	Section[b]		
Applied Load	Init.[a] Average	ABCF	EFGH	IJKL	Calc. Avg.	Error %[c]

[a]This field is blank for initial calibration of bar. For subsequent verifications this field will contain the initial average.
[b]Load @ section to be calculated as follows:
1. Calculate the average area (AV) at each section using the diameters from the claibration bar Form B.1
2. Calculate the average axial stress at each section from the data for that step number.
3. Multiply the average axial average stress by the average area to obtain the calculated load @ section.
[c]The percent error is calculated as follows:
Error = [(init. avg. - calc. avg.)/init. avg.] 100.

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

Table 17—Determination of Internal Test Pressure for Various Axial Loads and *t/D*'s at 95 Percent of Yield Strength

	T/T$_y$								
	-0.500	-0.400	-0.200	0.000	0.600	0.850	0.900	0.950	
t_s/D	P$_i$/P$_y$								t_s/D
0.020	0.535	0.613	0.741	0.839	0.945	0.867	0.833	0.788	0.020
0.022	0.537	0.615	0.743	0.840	0.945	0.865	0.830	0.784	0.022
0.024	0.539	0.617	0.745	0.842	0.944	0.862	0.827	0.780	0.024
0.026	0.541	0.619	0.747	0.843	0.944	0.860	0.824	0.777	0.026
0.028	0.543	0.621	0.748	0.845	0.943	0.858	0.821	0.773	0.028
0.030	0.545	0.623	0.750	0.846	0.942	0.855	0.818	0.769	0.030
0.032	0.547	0.625	0.752	0.848	0.942	0.853	0.815	0.765	0.032
0.034	0.549	0.626	0.754	0.849	0.941	0.850	0.812	0.761	0.034
0.036	0.551	0.628	0.756	0.851	0.941	0.848	0.809	0.757	0.036
0.038	0.553	0.630	0.757	0.852	0.940	0.845	0.806	0.753	0.038
0.040	0.555	0.632	0.759	0.854	0.939	0.843	0.803	0.749	0.040
0.042	0.557	0.634	0.761	0.855	0.939	0.840	0.800	0.745	0.042
0.044	0.559	0.636	0.763	0.856	0.938	0.838	0.797	0.741	0.044
0.046	0.561	0.638	0.765	0.858	0.937	0.835	0.794	0.737	0.046
0.048	0.563	0.640	0.766	0.859	0.937	0.833	0.790	0.733	0.048
0.050	0.565	0.642	0.768	0.861	0.936	0.830	0.787	0.729	0.050
0.052	0.567	0.644	0.770	0.862	0.935	0.828	0.784	0.725	0.052
0.054	0.568	0.646	0.771	0.863	0.935	0.825	0.781	0.721	0.054
0.056	0.570	0.648	0.773	0.865	0.934	0.822	0.777	0.716	0.056
0.058	0.572	0.650	0.775	0.866	0.933	0.820	0.774	0.712	0.058
0.060	0.574	0.652	0.777	0.867	0.932	0.817	0.771	0.708	0.060
0.062	0.576	0.653	0.778	0.869	0.931	0.814	0.767	0.704	0.062
0.064	0.578	0.655	0.780	0.870	0.930	0.812	0.764	0.699	0.064
0.066	0.580	0.657	0.782	0.871	0.930	0.809	0.761	0.695	0.066
0.068	0.582	0.659	0.783	0.872	0.929	0.806	0.757	0.691	0.068
0.070	0.584	0.661	0.785	0.874	0.928	0.803	0.754	0.686	0.070
0.072	0.586	0.663	0.787	0.875	0.927	0.801	0.750	0.682	0.072
0.074	0.588	0.665	0.788	0.876	0.926	0.798	0.747	0.677	0.074
0.076	0.590	0.667	0.790	0.877	0.925	0.795	0.744	0.673	0.076
0.078	0.592	0.669	0.791	0.879	0.924	0.792	0.740	0.668	0.078
0.080	0.594	0.670	0.793	0.880	0.923	0.790	0.737	0.664	0.080
0.082	0.595	0.672	0.795	0.881	0.922	0.787	0.733	0.659	0.082
0.084	0.597	0.674	0.796	0.882	0.921	0.784	0.730	0.655	0.084
0.086	0.599	0.676	0.798	0.883	0.920	0.781	0.726	0.650	0.086
0.088	0.601	0.678	0.799	0.884	0.919	0.778	0.723	0.646	0.088
0.090	0.603	0.680	0.801	0.886	0.918	0.775	0.719	0.641	0.090
0.092	0.605	0.681	0.802	0.887	0.917	0.772	0.716	0.636	0.092
0.094	0.607	0.683	0.804	0.888	0.916	0.770	0.712	0.632	0.094
0.096	0.609	0.685	0.806	0.889	0.915	0.767	0.708	0.627	0.096
0.098	0.611	0.687	0.807	0.890	0.914	0.764	0.705	0.622	0.098
0.100	0.612	0.689	0.809	0.891	0.913	0.761	0.701	0.168	0.100

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

STD.API/PETRO RP 5C5-ENGL 1996 ■ 0732290 0561989 588 ■

Table 17—Determination of Internal Test Pressure for Various Axial Loads and t/D's at 95 Percent of Yield Strength (Continued)

	T/Ty								
	-0.500	-0.400	-0.200	0.000	0.600	0.850	0.900	0.950	
ts/D	Pi/Py								ts/D
0.102	0.614	0.690	0.810	0.892	0.912	0.758	0.698	0.613	0.102
0.104	0.616	0.692	0.812	0.893	0.911	0.755	0.694	0.608	0.104
0.106	0.618	0.694	0.813	0.894	0.910	0.752	0.691	0.604	0.106
0.108	0.620	0.696	0.814	0.895	0.909	0.749	0.687	0.599	0.108
0.110	0.622	0.697	0.816	0.896	0.907	0.746	0.683	0.594	0.110
0.112	0.623	0.699	0.817	0.897	0.906	0.743	0.680	0.589	0.112
0.114	0.625	0.701	0.819	0.898	0.905	0.740	0.676	0.585	0.114
0.116	0.627	0.703	0.820	0.899	0.904	0.737	0.673	0.580	0.116
0.118	0.629	0.704	0.822	0.900	0.903	0.735	0.669	0.575	0.118
0.120	0.631	0.706	0.823	0.901	0.902	0.732	0.665	0.570	0.120
0.122	0.633	0.708	0.824	0.902	0.900	0.729	0.662	0.565	0.122
0.124	0.634	0.710	0.826	0.903	0.899	0.726	0.658	0.561	0.124
0.126	0.636	0.711	0.827	0.904	0.898	0.723	0.654	0.556	0.126
0.128	0.638	0.713	0.829	0.905	0.897	0.720	0.651	0.551	0.128
0.130	0.640	0.715	0.830	0.906	0.896	0.717	0.647	0.546	0.130
0.132	0.642	0.716	0.831	0.907	0.894	0.714	0.644	0.541	0.132
0.134	0.643	0.718	0.833	0.908	0.893	0.711	0.640	0.536	0.134
0.136	0.645	0.720	0.834	0.908	0.892	0.708	0.637	0.532	0.136
0.138	0.647	0.721	0.835	0.909	0.891	0.705	0.633	0.527	0.138
0.140	0.649	0.723	0.836	0.910	0.889	0.702	0.629	0.522	0.140
0.142	0.650	0.725	0.838	0.911	0.888	0.699	0.626	0.517	0.142
0.144	0.652	0.726	0.839	0.912	0.887	0.696	0.622	0.512	0.144
0.146	0.654	0.728	0.840	0.913	0.886	0.693	0.619	0.507	0.146
0.148	0.656	0.729	0.842	0.913	0.884	0.691	0.615	0.503	0.148
0.150	0.657	0.731	0.843	0.914	0.883	0.688	0.612	0.498	0.150
0.152	0.659	0.733	0.844	0.915	0.882	0.685	0.608	0.493	0.152
0.154	0.661	0.734	0.845	0.916	0.881	0.682	0.604	0.488	0.154
0.156	0.662	0.736	0.846	0.916	0.879	0.679	0.601	0.483	0.156
0.158	0.664	0.737	0.848	0.917	0.878	0.676	0.597	0.478	0.158
0.160	0.666	0.739	0.849	0.918	0.877	0.673	0.594	0.473	0.160
0.162	0.667	0.740	0.850	0.919	0.875	0.670	0.590	0.469	0.162
0.164	0.669	0.742	0.851	0.919	0.874	0.668	0.587	0.464	0.164
0.166	0.671	0.743	0.852	0.920	0.873	0.665	0.584	0.459	0.166
0.168	0.672	0.745	0.853	0.921	0.871	0.662	0.580	0.454	0.168
0.170	0.674	0.746	0.855	0.921	0.870	0.659	0.577	0.449	0.170
0.172	0.676	0.748	0.856	0.922	0.869	0.656	0.573	0.445	0.172
0.174	0.677	0.749	0.857	0.923	0.868	0.653	0.570	0.440	0.174
0.176	0.679	0.751	0.858	0.923	0.866	0.651	0.566	0.435	0.176
0.178	0.680	0.752	0.859	0.924	0.865	0.648	0.563	0.430	0.178
0.180	0.682	0.754	0.860	0.925	0.864	0.645	0.560	0.426	0.180
0.182	0.684	0.755	0.861	0.925	0.862	0.642	0.556	0.421	0.182
0.184	0.685	0.757	0.862	0.926	0.861	0.639	0.553	0.416	0.184
0.186	0.687	0.758	0.863	0.926	0.860	0.637	0.550	0.411	0.186
0.188	0.688	0.759	0.864	0.927	0.858	0.634	0.546	0.407	0.188
0.190	0.689	0.761	0.865	0.927	0.857	0.631	0.543	0.402	0.190

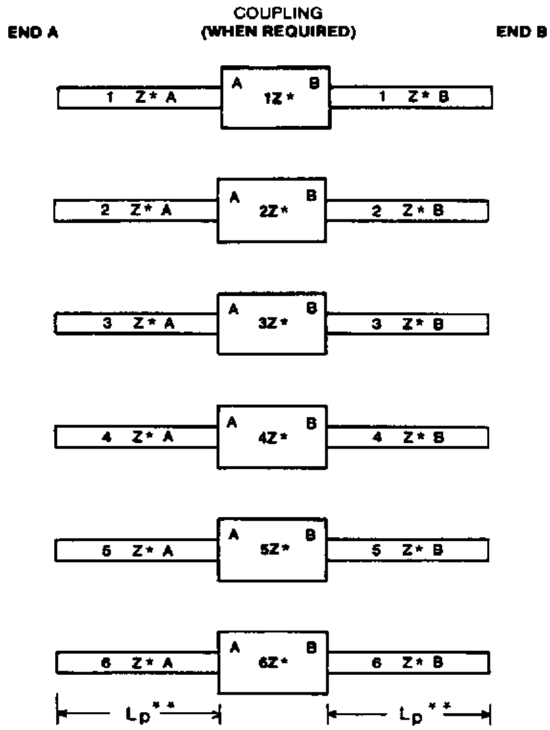
COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

Table 18—Determination of P_i/P_y for Various t/D's at Axial Load of 80 Percent of Yield Load and Internal Pressure for an Equivalent Stress of 90 Percent of Yield Stress

t_s/D	P_i/P_y	t_s/D	P_i/Y_y
0.020	0.824	0.102	0.723
0.022	0.822	0.104	0.721
0.024	0.820	0.106	0.718
0.026	0.818	0.108	0.715
0.028	0.816	0.110	0.713
0.030	0.813	0.112	0.710
0.032	0.811	0.114	0.707
0.034	0.809	0.116	0.704
0.036	0.807	0.118	0.702
0.038	0.805	0.120	0.699
0.040	0.802	0.122	0.696
0.042	0.800	0.124	0.694
0.044	0.798	0.126	0.691
0.046	0.795	0.128	0.688
0.048	0.793	0.130	0.685
0.050	0.790	0.132	0.683
0.052	0.788	0.134	0.680
0.054	0.786	0.136	0.677
0.056	0.783	0.138	0.674
0.058	0.781	0.140	0.672
0.060	0.778	0.142	0.669
0.062	0.776	0.144	0.666
0.064	0.773	0.146	0.664
0.066	0.771	0.148	0.661
0.068	0.768	0.150	0.658
0.070	0.766	0.152	0.656
0.072	0.763	0.154	0.653
0.074	0.761	0.156	0.650
0.076	0.758	0.158	0.647
0.078	0.755	0.160	0.645
0.080	0.753	0.162	0.642
0.082	0.750	0.164	0.640
0.084	0.747	0.166	0.637
0.086	0.745	0.168	0.634
0.088	0.742	0.170	0.632
0.090	0.740	0.172	0.629
0.092	0.737	0.174	0.626
0.094	0.734	0.176	0.624
0.096	0.732	0.178	0.621
0.098	0.729	0.180	0.619
0.100	0.726	0.182	0.616

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

STD.API/PETRO RP 5C5-ENGL 1996 ■ 0732290 0561991 136 ■



*This could be any of the specimen set letters found in Tables 3-10.

$$**L_p \geqq \left\{ D + 6\sqrt{Dt} \right\} \quad \text{WHERE} \quad \begin{cases} D = \text{Specified Pipe Diameter} \\ t = \text{Specified Pipe Thickness} \end{cases}$$

Note: L_p may need to be slightly longer on strain gauged specimens.

Figure 1—Specimen Nomenclature

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

Interference Thread	Interference Seal	Ring Groove Fill	Torque	Assembly	Interference Thread	Interference Seal	Ring Groove Fill	Torque
L	H	L	H	1 Z A* — A B 1Z — *1 Z B	H	H	H	H
H	L	H	H	2 Z A — A B 2Z — 2 Z B	L	L	L	H
H	L	H	L	3 Z A* — A B 3Z — 3 Z B	H	L	L	H
L	H	H	H	4 Z A — A B 4Z — 4 Z B	L	L	H	L
L	L	L	L	5 Z A — A B 5Z — 5 Z B	H	L	L	L
L	H	L	L	6 Z A — A B 6Z — 6 Z B	H	H	L	H

H = Maximum interference; Maximum ring groove fill; Maximum torque

L = Minimum interference; Minimum ring groove fill; Minimum torque

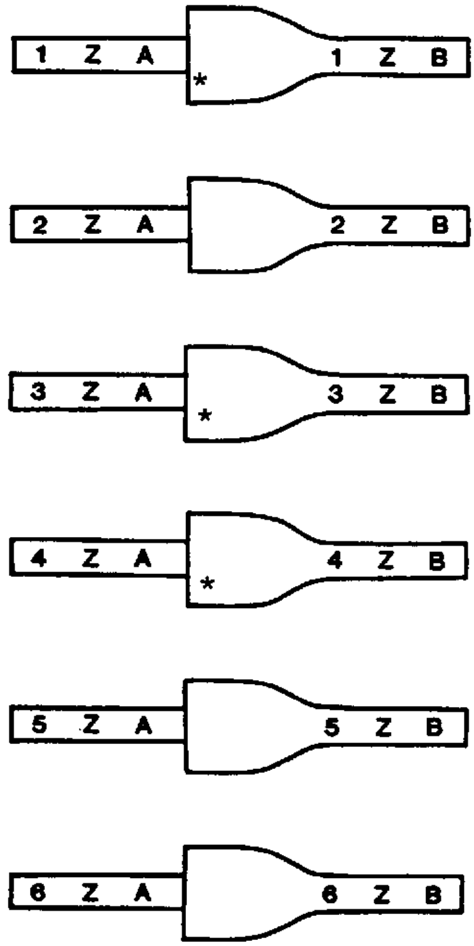
***Strain gauged assembly (Class I only)**

Figure 2—Connection Machining Requirements
Coupled with Torque Shoulder and Metal and Resilient Seals

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

STD·API/PETRO RP 5C5-ENGL 1996 ■ 0732290 0561993 T09 ■

INTERFERENCE		RING GROOVE	
THREAD	SEAL	FILL	TORQUE
L	H	L	H
H	L	H	H
H	L	H	L
H	H	H	H
L	L	L	L
L	H	L	L



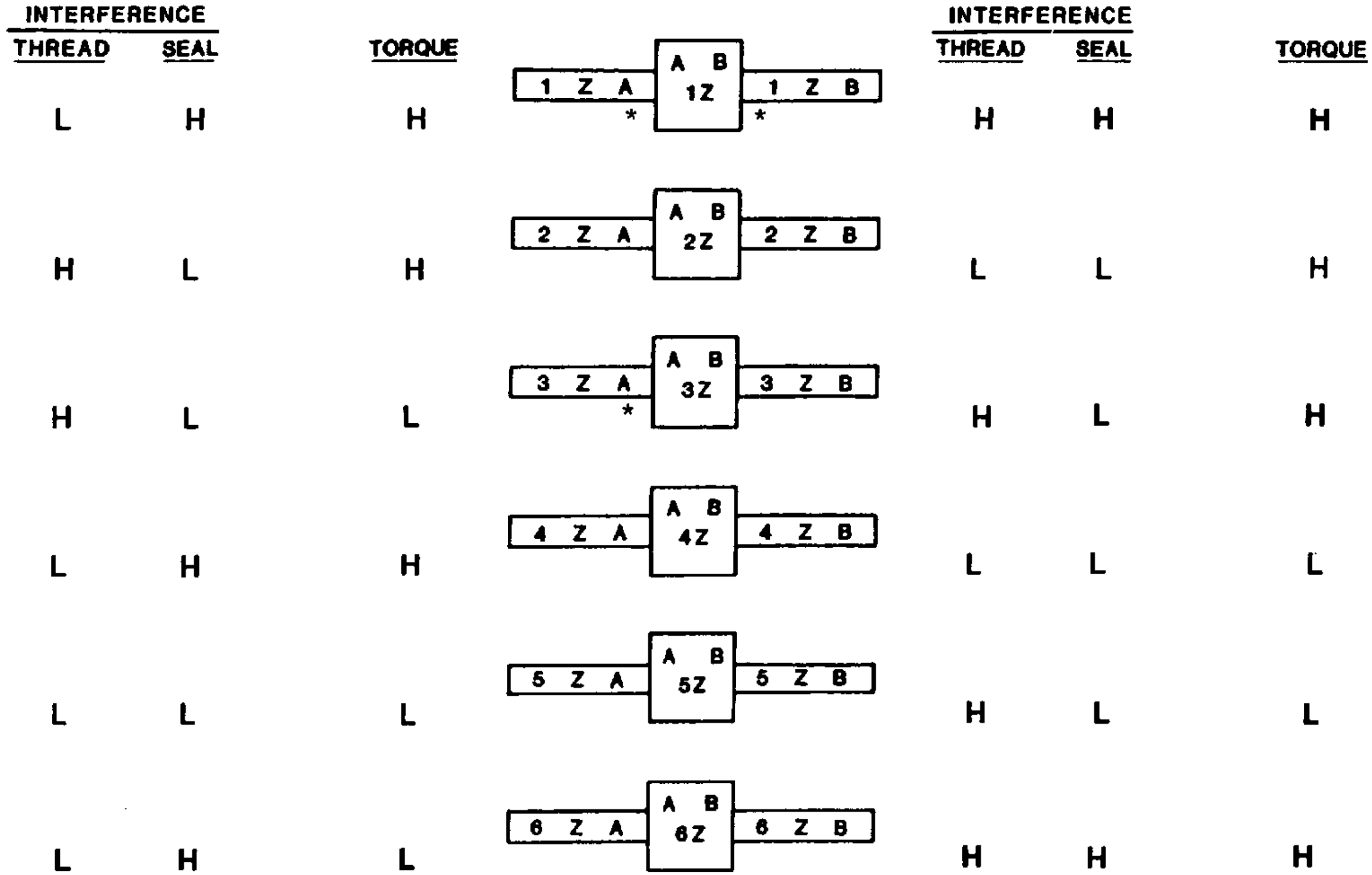
H = Maximum interference; Maximum ring groove fill; Maximum torque

L = Minimum interference; Minimum ring groove fill; Minimum torque

***Strain gauged assembly (Class I only)**

Figure 3—Connection Machining Requirements
Integral with Torque Shoulder and Metal and Resilient Seals

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

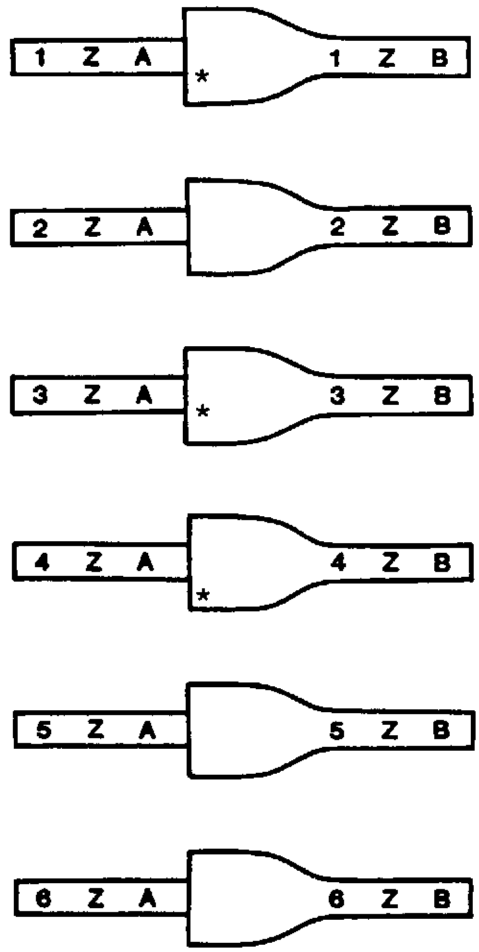


H = **Maximum interference; Maximum torque**
L = **Minimum interference; Minimum torque**
***Strain gauged assembly (Class I only)**

Figure 4—Connection Machining Requirements
Coupled with Torque Shoulder and Metal Seal but without Resilient Seal

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

INTERFERENCE		
THREAD	SEAL	TORQUE
L	H	H
H	L	H
H	L	L
H	H	H
L	L	L
L	H	L



H = Maximum interference; Maximum torque
L = Minimum interference; Minimum torque
***Strain gauged assembly (Class I only)**

Figure 5—Connection Machining Requirements
Integral with Torque Shoulder Metal Seal but without Resilient Seal

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

THREAD INTERFERENCE	RING GROOVE FILL	TORQUE	Connection	THREAD INTERFERENCE	RING GROOVE FILL	TORQUE
L	L	L	1 Z A · A B 1Z · 1 Z B	H	H	L
L	H	L	2 Z A · A B 2Z · 2 Z B	H	L	L
L	L	H	3 Z A · A B 3Z · 3 Z B	H	H	H
H	H	H	4 Z A · A B 4Z · 4 Z B	L	L	L
H	L	H	5 Z A · A B 5Z · 5 Z B	L	H	L
L	H	H	6 Z A · A B 6Z · 6 Z B	L	L	H

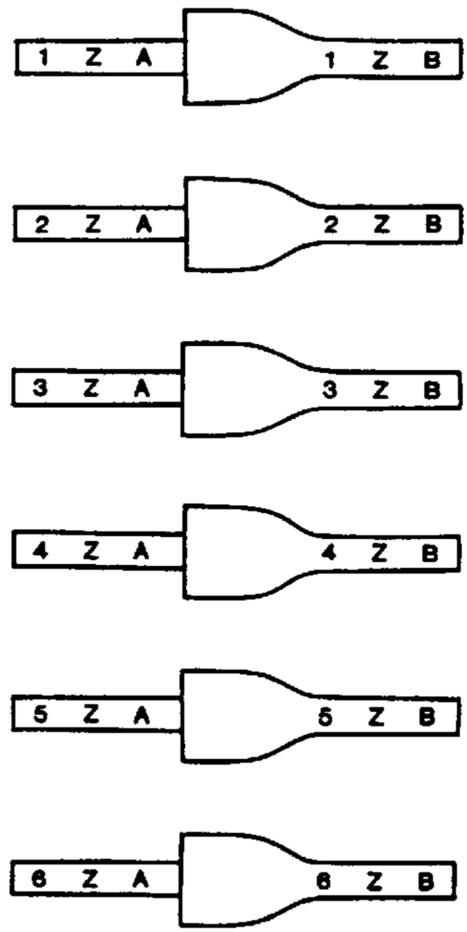
H = Maximum (fast) taper; Maximum ring groove fill; Maximum torque
L = Minimum (slow) taper; Minimum ring groove fill; Minimum torque
***May also be used for a wedge thread with or without a resilient seal.**

Figure 6—Connection Machining Requirements
Coupled with Torque Shoulder and Resilient Seal but without Metal Seal*

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

STD·API/PETRO RP 5C5-ENGL 1996 ■ 0732290 0561997 654 ■

THREAD INTERFERENCE	RING GROOVE FILL	TORQUE
L	L	L
L	H	L
L	L	H
H	H	H
H	L	H
L	H	H



H = Maximum interference; Maximum ring groove fill; Maximum torque

L = Minimum interference; Minimum ring groove fill; Minimum torque

***May also be used for a wedge thread with or without a resilient seal.**

Figure 7—Connection Machining Requirements
Integral with Torque Shoulder and Resilient Seal but without Metal Seal*

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

TAPER BOX	TAPER PIN	RING* GROOVE FILL	TORQUE	Coupling	TAPER BOX	TAPER PIN	RING* GROOVE FILL	TORQUE
L	H	L	L	1 Z A / A B 1Z / 1 Z B	H	L	H	H
H	L	L	H	2 Z A / A B 2Z / 2 Z B	L	H	H	L
A	A	L	L	3 Z A / A B 3Z / 3 Z B	H	H	H	L
H	L	H	L	4 Z A / A B 4Z / 4 Z B	A	A	L	H
L	L	H	H	5 Z A / A B 5Z / 5 Z B	L	H	L	H
L	H	H	H	6 Z A / A B 6Z / 6 Z B	H	L	L	L

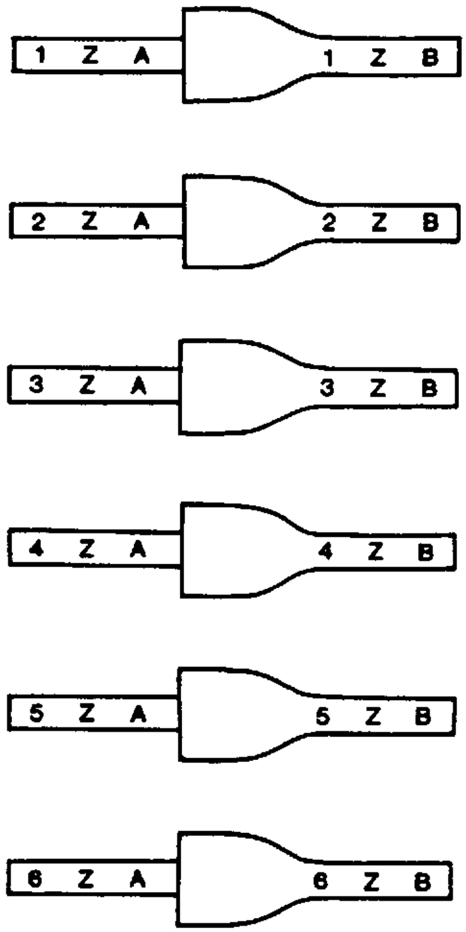
H = Maximum (fast) taper; Maximum ring groove fill; Maximum torque
L = Minimum (slow) taper; Minimum ring groove fill; Minimum torque
A = Average taper
*** The maximum box pitch diameter is required when high seal ring fill is specified and the minimum box pitch diameter is required when the low seal ring fill is specified.**

Figure 8—Connection Machining Requirements
Coupled with Resilient Seal but without Metal Seal and Torque Shoulder

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

STD.API/PETRO RP 5C5-ENGL 1996 ■ 0732290 0561999 427 ■

TAPER BOX	TAPER PIN	RING* GROOVE FILL	TORQUE
L	H	L	L
H	L	L	H
A	A	L	L
H	L	H	L
L	L	H	H
L	H	H	H



H = Maximum (fast) taper; Maximum ring groove fill; Maximum torque
L = Minimum (slow) taper; Minimum ring groove fill; Minimum torque
A = Average

*** The maximum box pitch diameter is required when high seal ring fill is specified and the minimum box pitch diameter is required when the low seal ring fill is specified.**

Figure 9—Connection Machining Requirements
Integral with Resilient Seal but without Metal Seal and Torque Shoulder

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

STD.API/PETRO RP 5C5-ENGL 1996 ■ 0732290 0562000 847 ■

TAPER BOX	TAPER PIN	TORQUE	Coupling	TAPER BOX	TAPER PIN	TORQUE
L	H	L	1 Z A — A B 1Z — 1 Z B	H	L	H
H	L	H	2 Z A — A B 2Z — 2 Z B	L	H	L
A	A	L	3 Z A — A B 3Z — 3 Z B	H	H	L
H	L	L	4 Z A — A B 4Z — 4 Z B	A	A	H
L	L	H	5 Z A — A B 5Z — 5 Z B	L	H	H
L	H	H	6 Z A — A B 6Z — 6 Z B	H	L	L

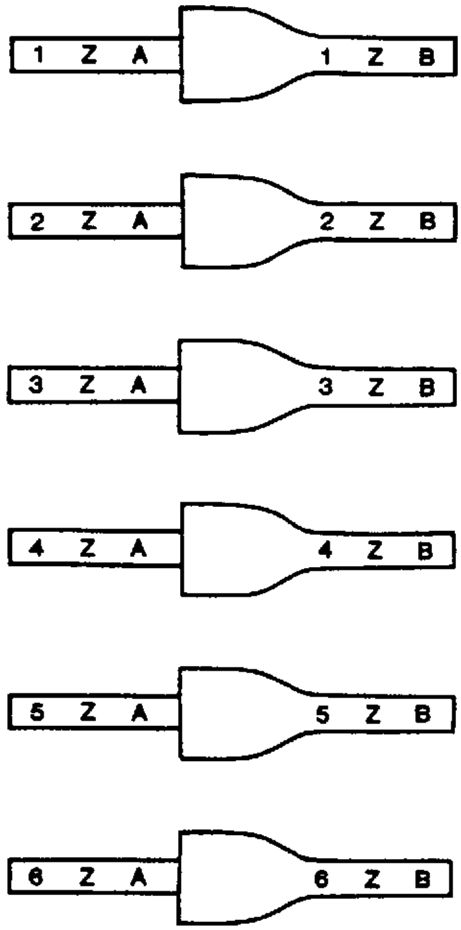
H = Maximum (fast) taper; Maximum torque
L = Minimum (slow) taper; Minimum torque
A = Average

Figure 10—Connection Machining Requirements
Coupled with Thread Seal Only and without Torque Shoulder

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

STD.API/PETRO RP 5C5-ENGL 1996 ■■ 0732290 0562001 783 ■■

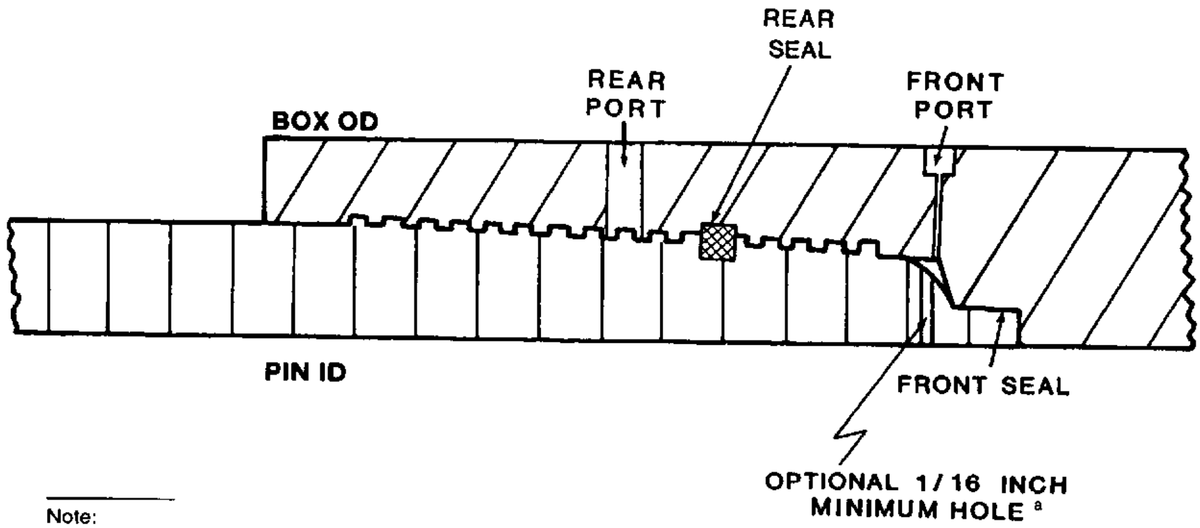
TAPER BOX	TAPER PIN	TORQUE
L	H	L
H	L	H
A	A	L
H	L	L
L	L	H
L	H	H



H = **Maximum (fast) taper; Maximum torque**
L = **Minimum (slow) taper; Minimum torque**
A = **Average**

Figure 11—Connection Machining Requirements
Integral with Thread Seal Only and without Torque Shoulder

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000



Note:

[a] For combined loading failure tests (Test 4.45) this hole can replace the front leak observation port except on those specimens to be strain gauged.

Figure 12—Leak Observation Ports

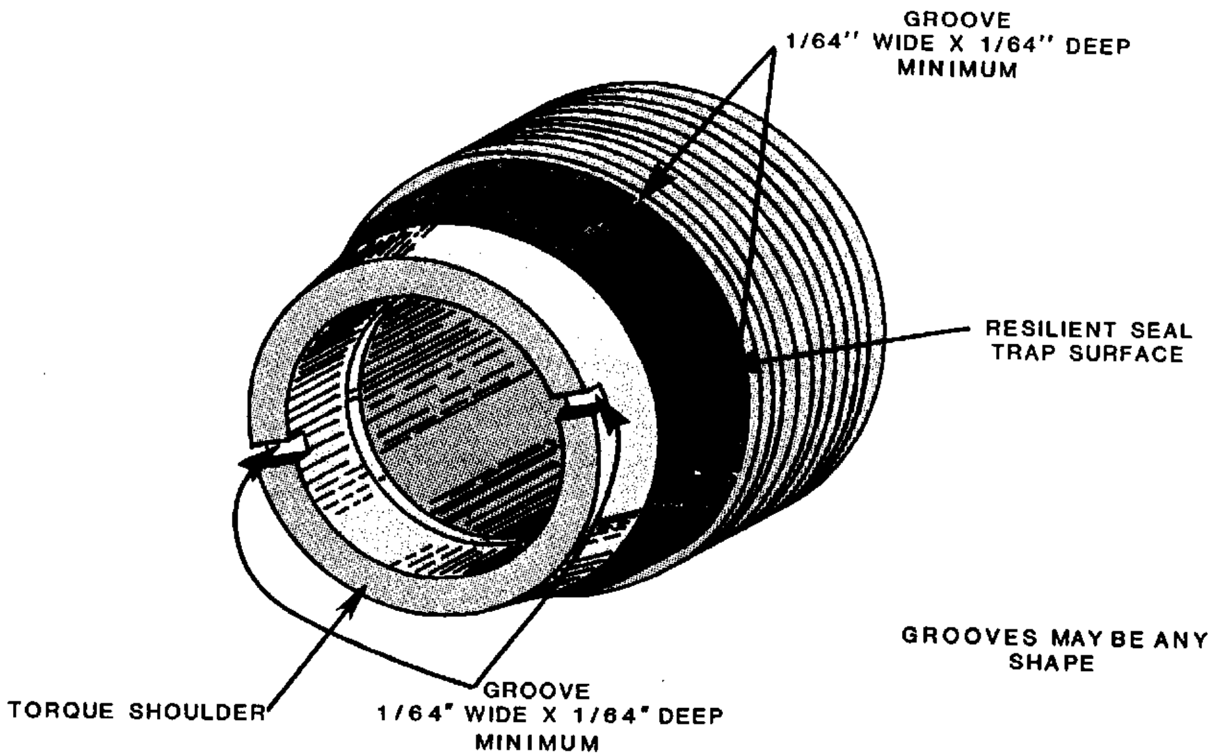
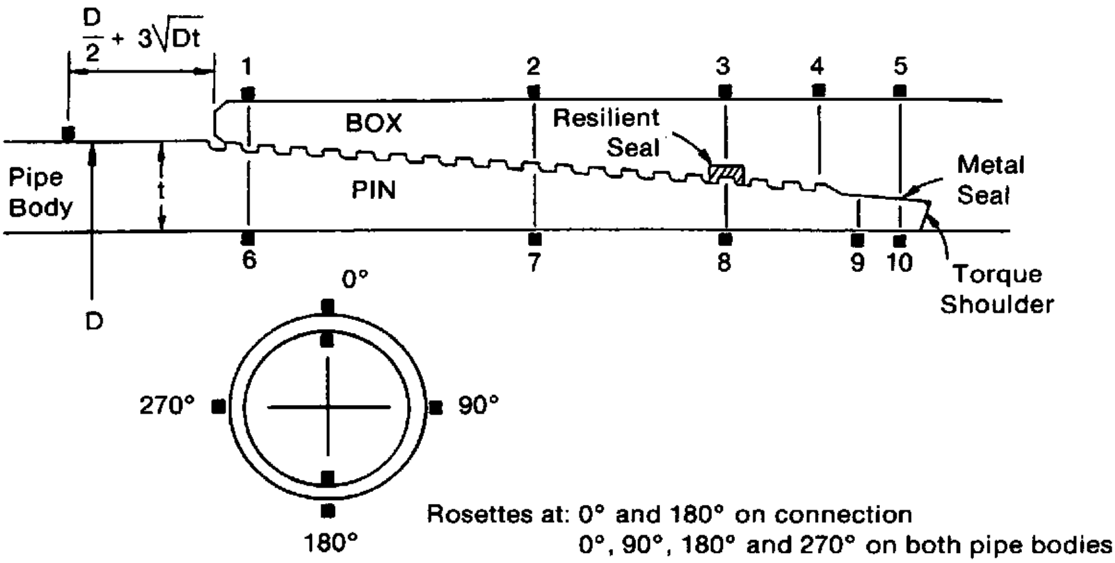


Figure 13—Pin Crippling Grooves

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

STD.API/PETRO RP 5C5-ENGL 1996 ■ 0732290 0562003 556 ■

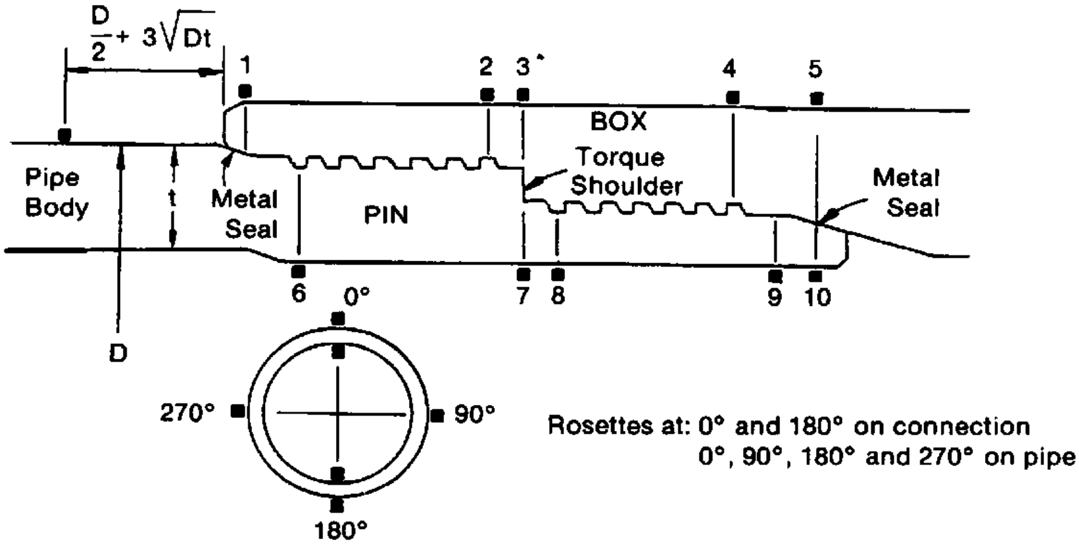


Location	Description
1	End of Box
2	Center of threads
3	Box groove for resilient seal
4	Box critical section
5	Inside metal-to-metal seal
6	Pin critical section
7	Center of threads
8	Resilient seal
9	Mid-way between metal seal and first thread
10	Inside metal-to-metal seal

Each location to have a two-element 90° Rosette with a grid size of ⅛" × ⅛" per element. Total of at least 20 rosettes per connection and 4 per pipe body.

Figure 14—Strain Gauge Locations for Tapered Connections with Thread Interference

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000



Location	Description
1	Outside seal
2	Large step box critical section
3	Torque shoulder
4	Small step box critical section
5	Inside metal-to-metal seal
6	Large step pin critical section
7	Torque shoulder
8	Small step critical section
9	Mid-way between metal seal and first thread
10	Inside metal-to-metal seal

Each location to have a two-element 90° Rosette with a grid size of ⅛" × ⅛" per element. Total of at least 20 rosettes per connection and 4 per pipe body.

Figure 15—Strain Gauge Locations for Two-Step Connections

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

STD.API/PETRO RP 5C5-ENGL 1996 ■ 0732290 0562005 329 ■

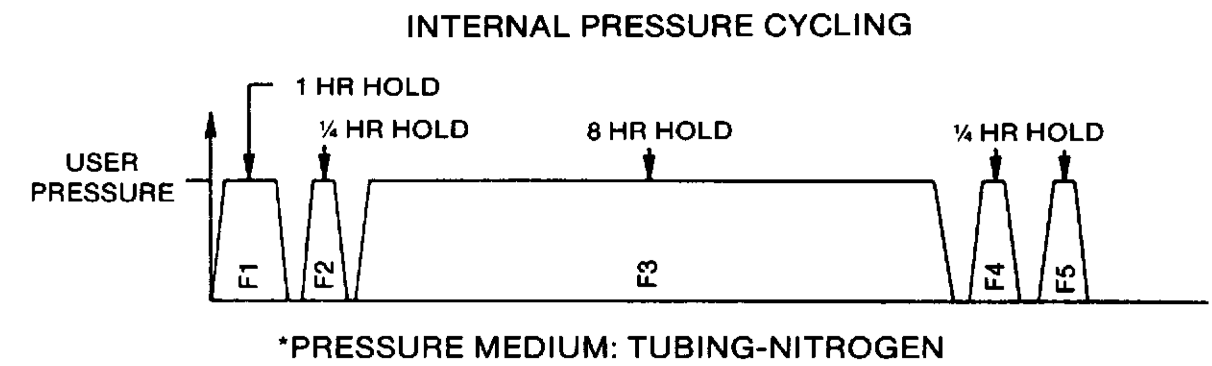


Figure 16—Test 4.3.1 Initial Capped-end Pressure* Cycling (at Room Temperature)

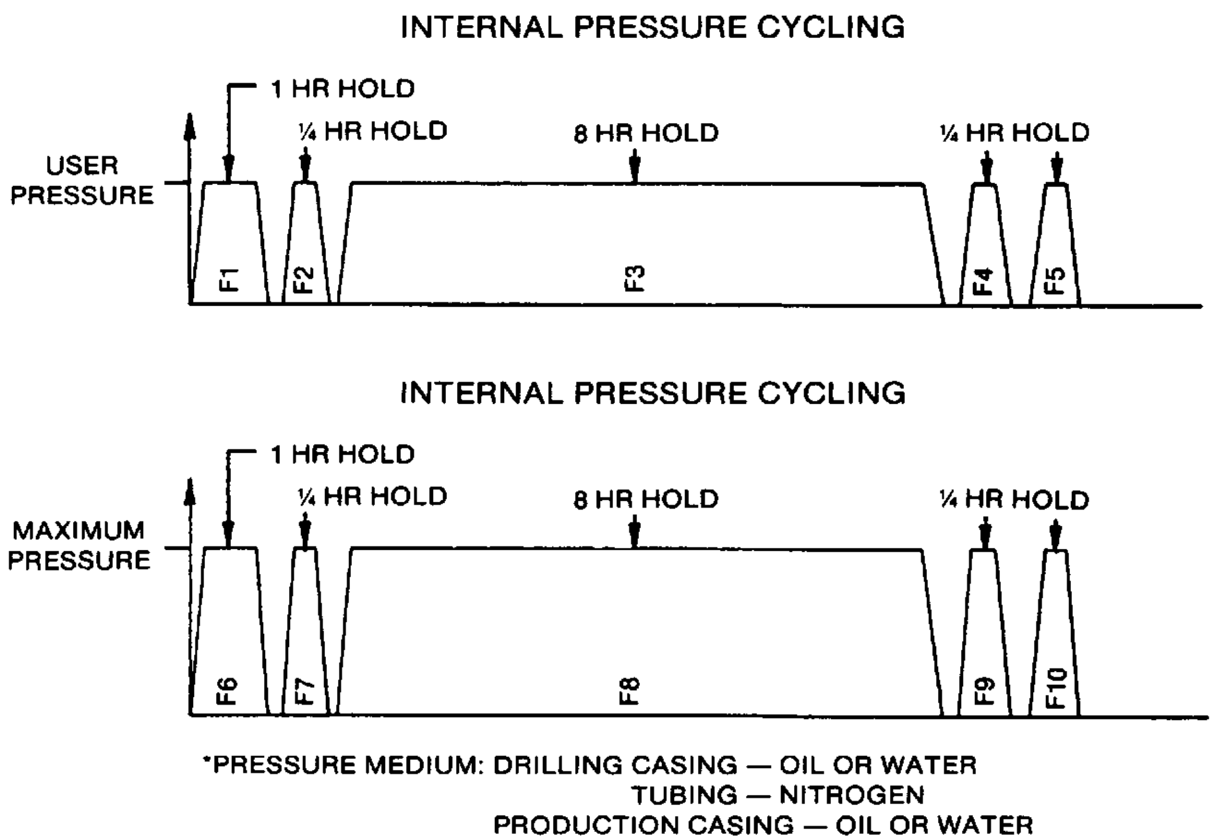
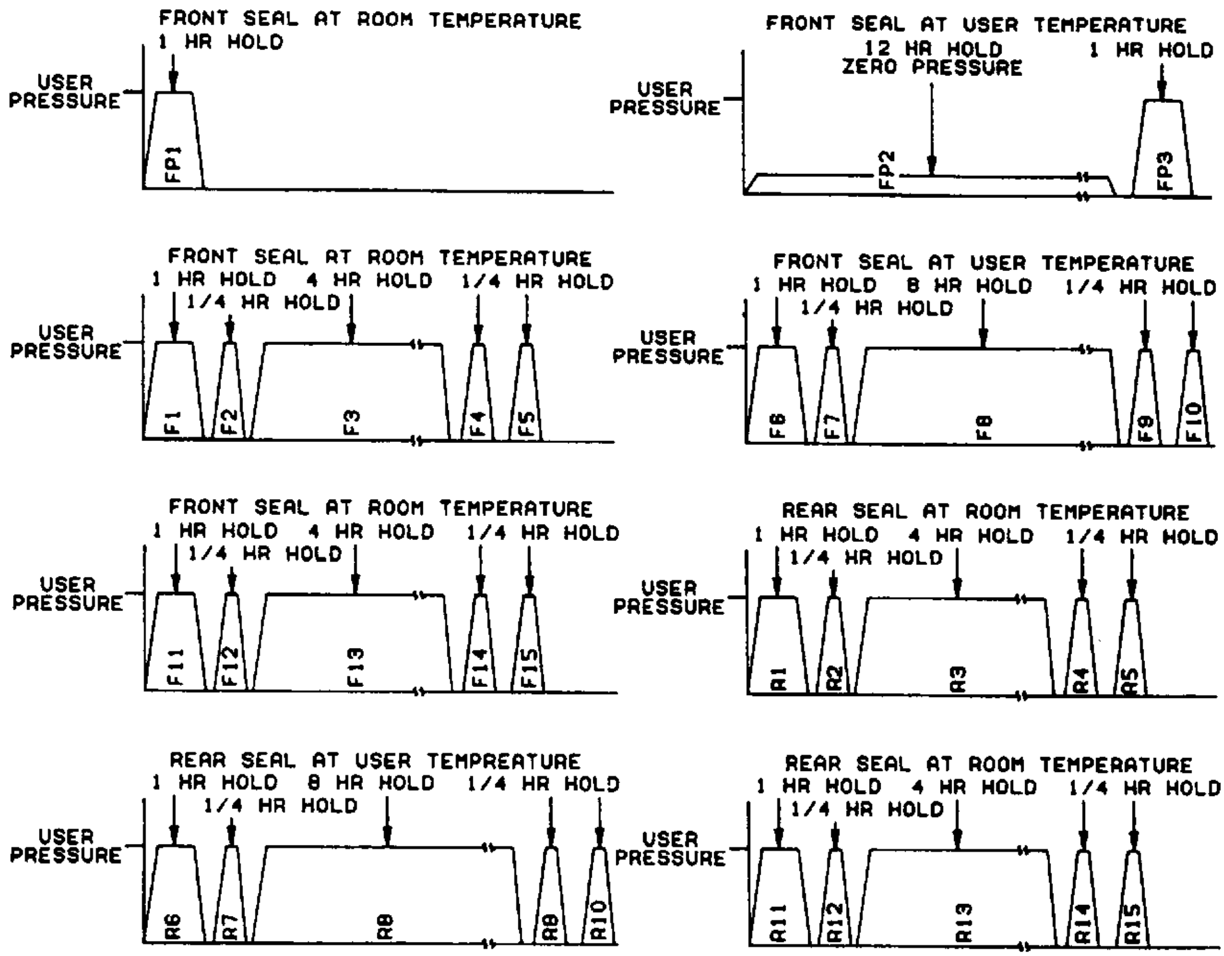


Figure 17—Test 4.3.2 Final Capped-end Pressure* Cycling (at Room Temperature)

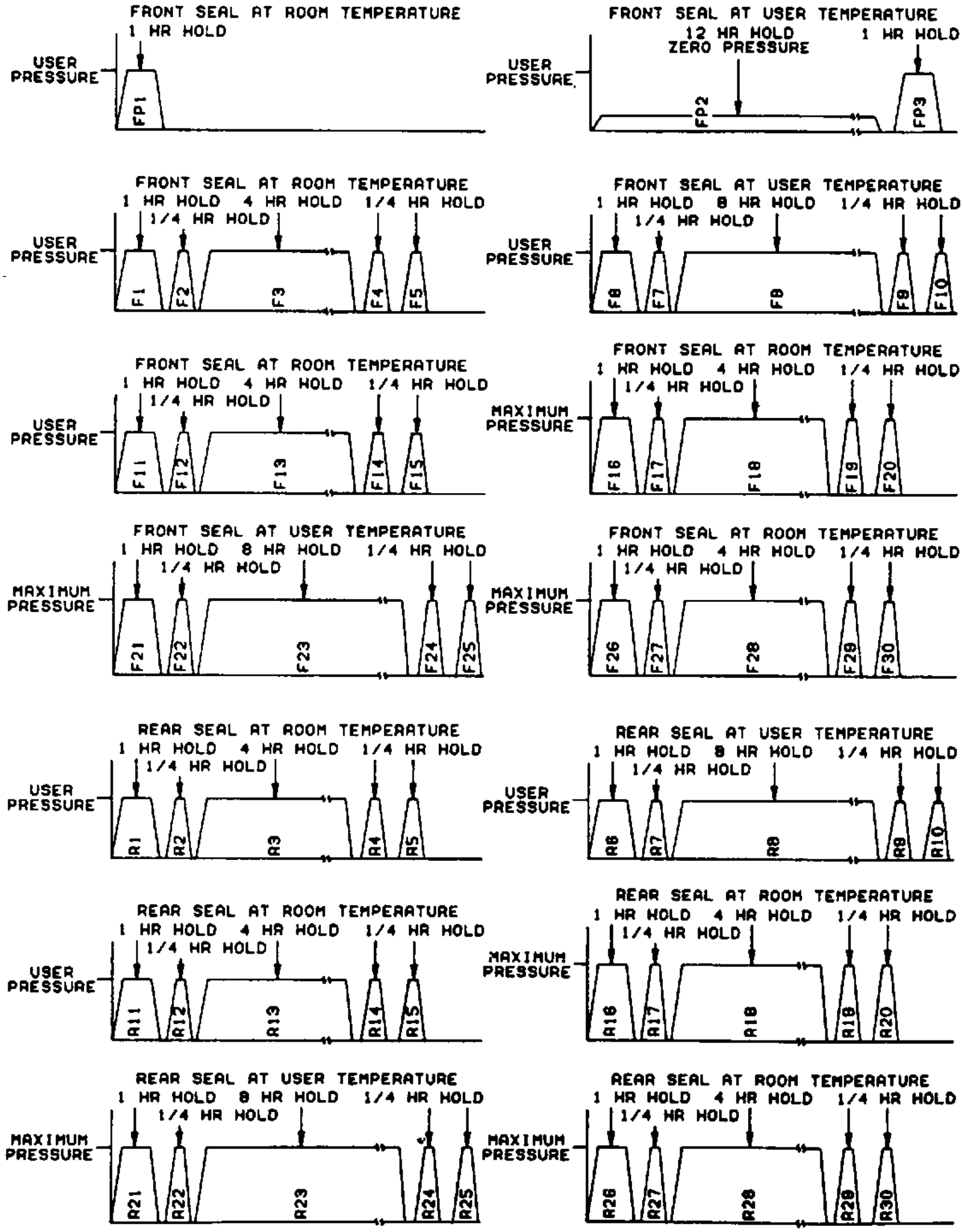
COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000



* PRESSURE MEDIUM: TUBING-NITROGEN

Figure 18—Initial Capped-end Pressure* Cycling with Thermal Cycling

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000



*PRESSURE MEDIUM: PRODUCTION CASING — NITROGEN
DRILLING — CASING OIL OR WATER
TUBING — NITROGEN

Figure 19—Test 4.3.4 Final Capped-end Pressure* Cycling with Thermal Cycling

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

STD·API/PETRO RP 5C5-ENGL 1996 ■ 0732290 0562008 038 ■

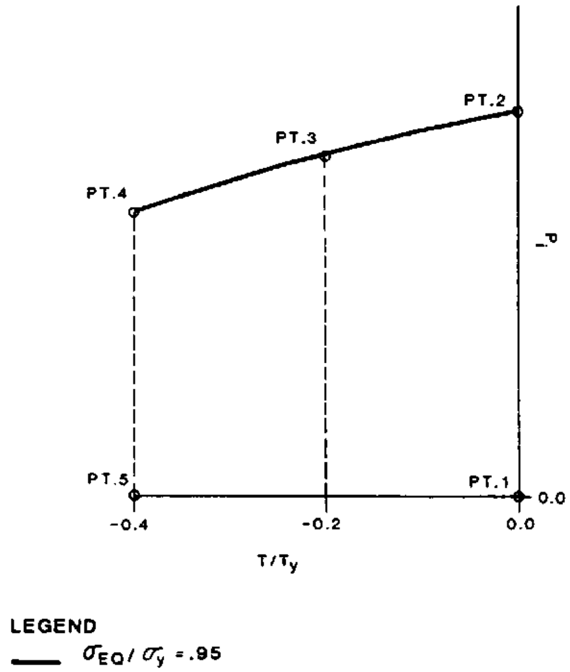


Figure 20—Test 4.3.5 Compression/ID Pressure Loan Limits

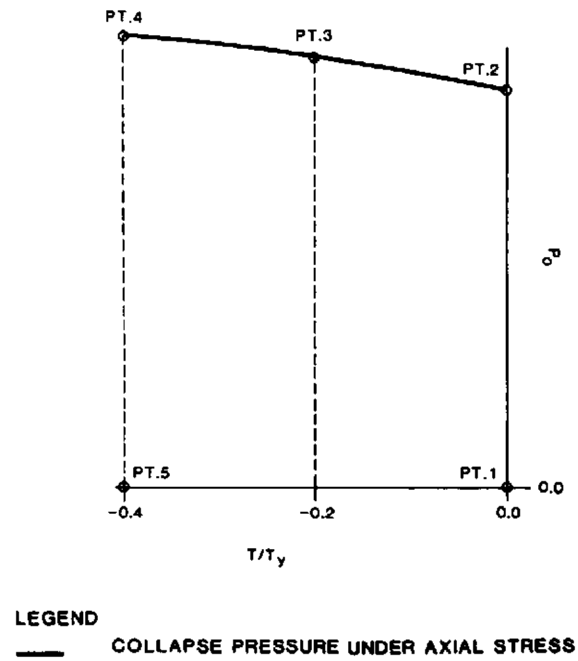
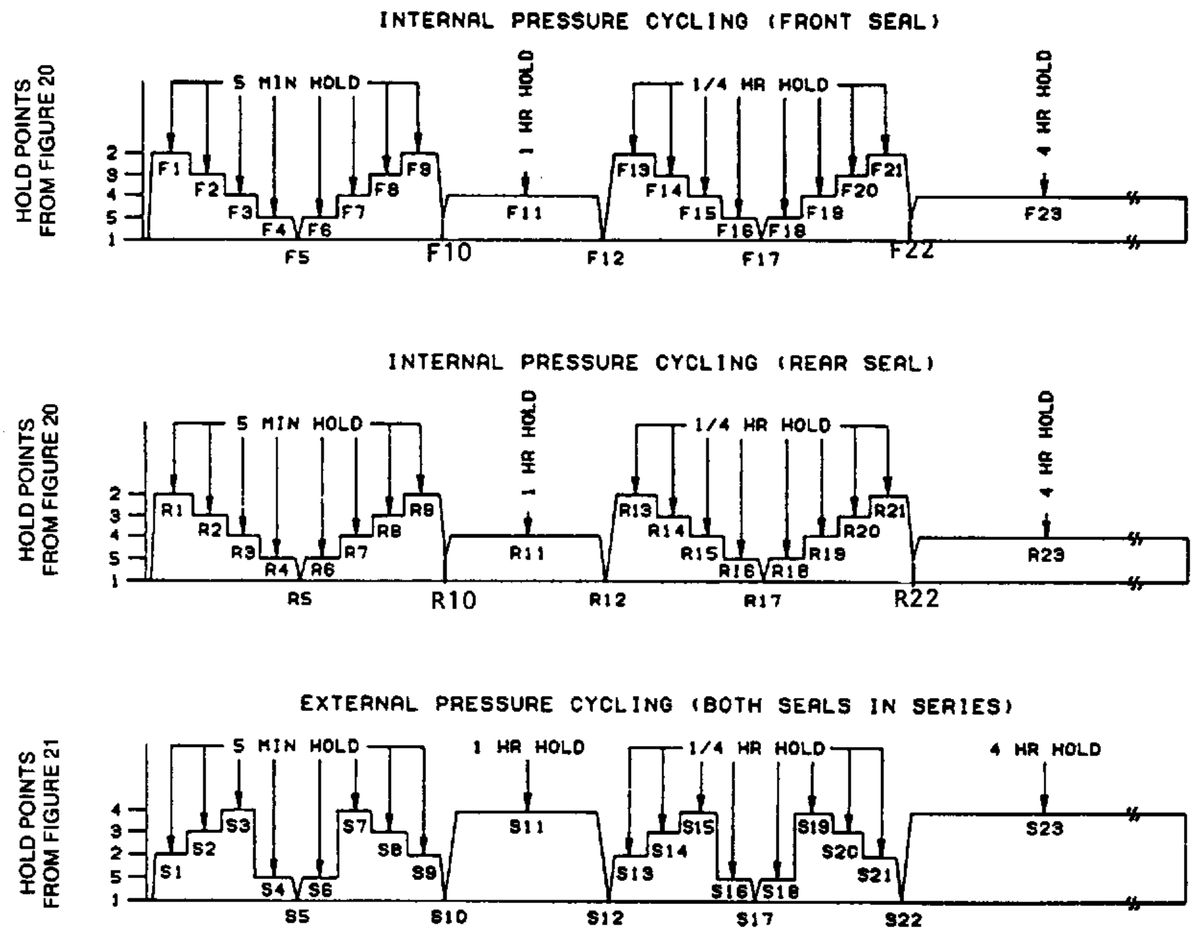


Figure 21—Test 4.3.5 Compression/OD Pressure Loan Limits

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000



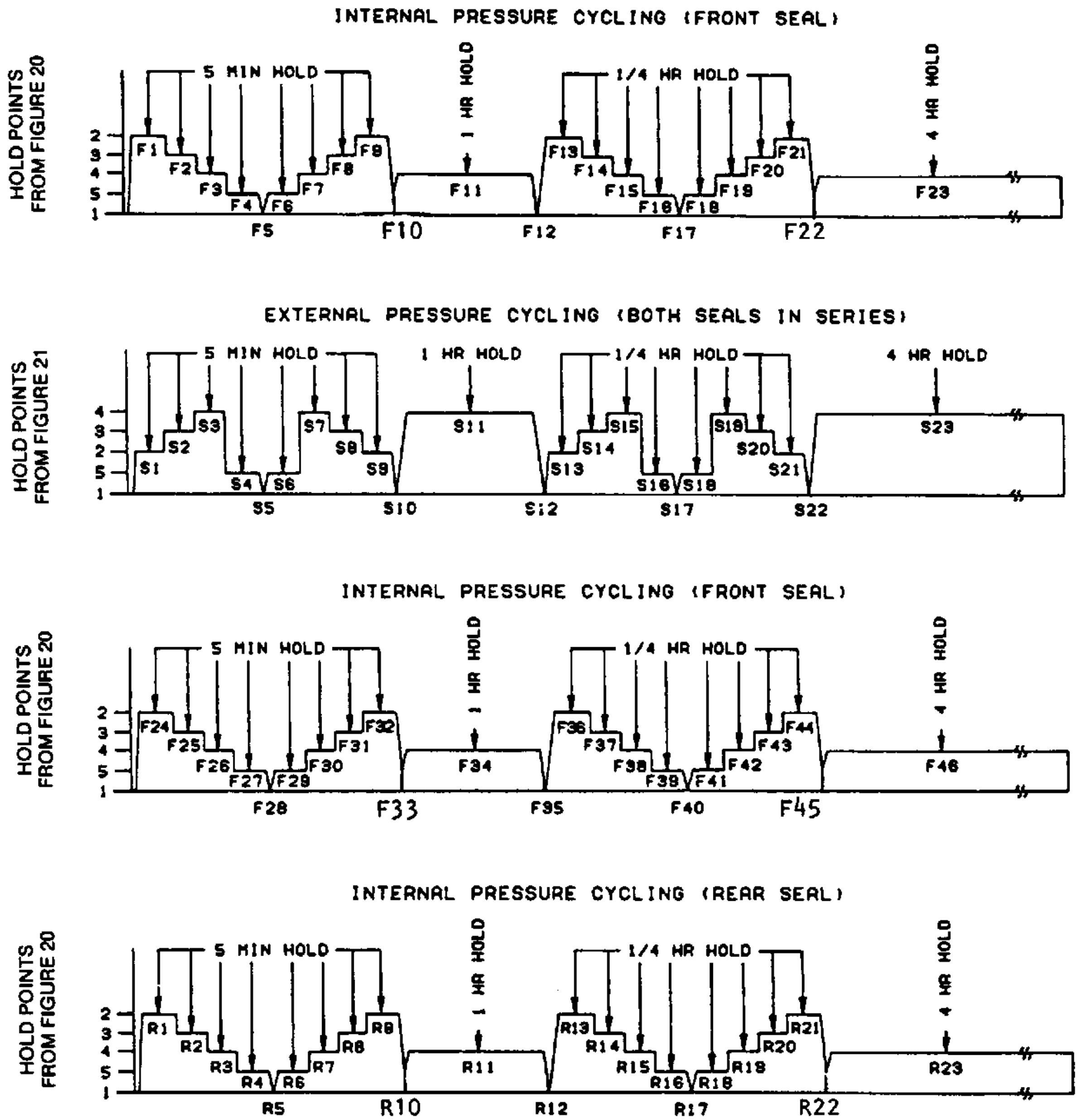
*PRESSURE MEDIUM: INTERNAL — NITROGEN
EXTERNAL — OIL OR WATER

TEST PRECEDED BY 24 HR HOLD AT 0 PSIG
AND USER TEMPERATURE

Figure 22—Test 4.3.5 (Casing) Compression and Internal/External Pressure* Cycling (at Room Temperature)

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

STD.API/PETRO RP 5C5-ENGL 1996 ■ 0732290 0562010 796 ■



*PRESSURE MEDIUM: INTERNAL — NITROGEN
EXTERNAL — OIL OR WATER

TEST PRECEDED BY 24 HR HOLD AT 0 PSIG
AND USER TEMPERATURE

Figure 23—Test 4.3.5 (Tubing) Compression and Internal/External Pressure* Cycling (at Room Temperature)

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

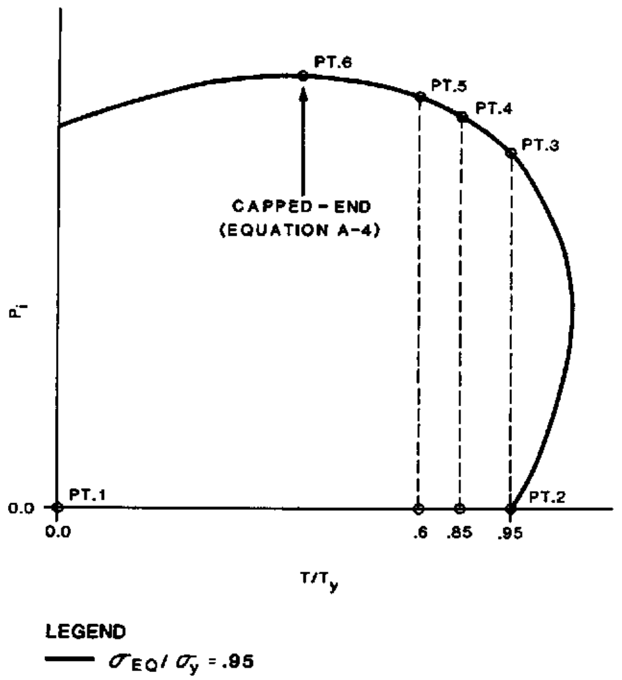


Figure 24—Test 4.3.7 & 4.3.8 Tension/ID Pressure Loan Limits

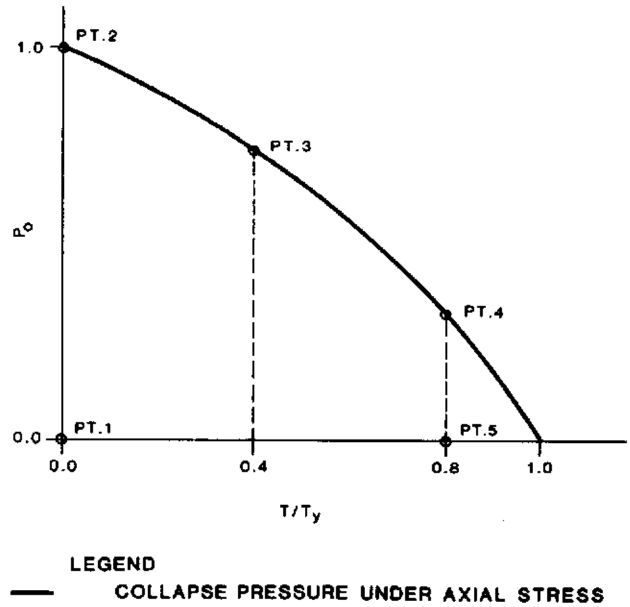
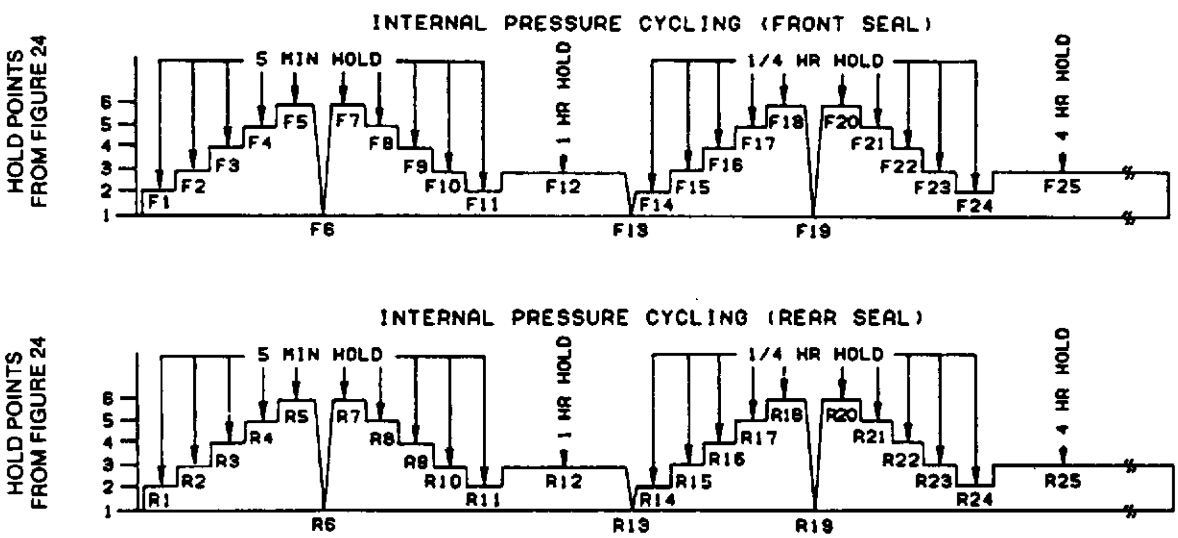


Figure 26—Test 4.3.8 Tension/OD Pressure Loan Limits

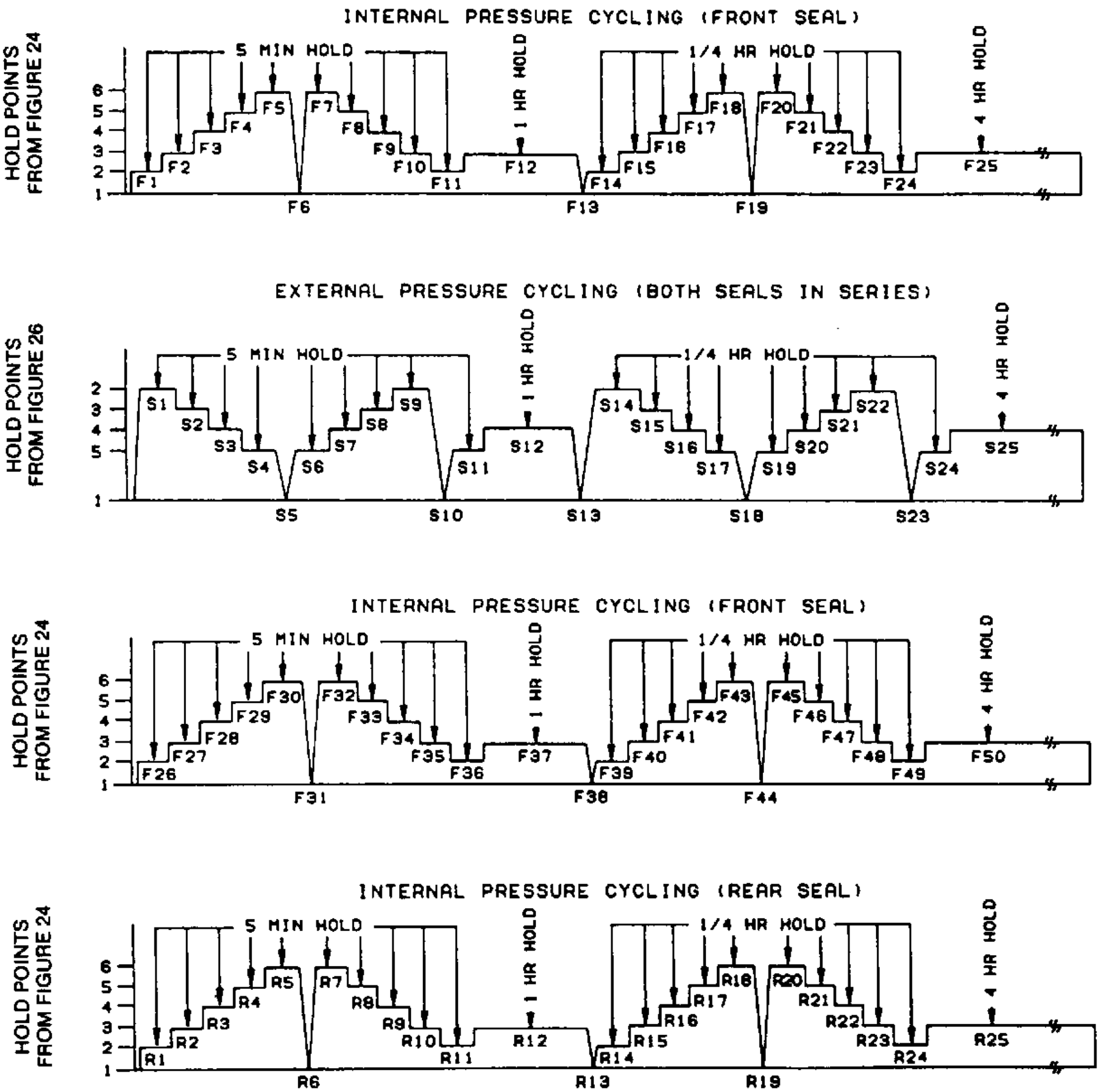


*PRESSURE MEDIUM: PRODUCTION CASING — NITROGEN
DRILLING CASING — OIL OR WATER

TEST PRECEDED BY 24 HR HOLD AT 0 PSIG
AND USER TEMPERATURE

Figure 25—Test 4.3.7 Tension and Internal Pressure* Cycling (at Room Temperature)

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000



*PRESSURE MEDIUM: TUBING — INTERNAL — NITROGEN
EXTERNAL — OIL OR WATER
TEST PRECEDED BY 24 HR HOLD AT 0 PSIG
AND USER TEMPERATURE

Figure 27—Test 4.3.8 Tension and Internal/External Pressure* Cycling (at Room Temperature)

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

STD.API/PETRO RP 5C5-ENGL 1996 ■ 0732290 0562013 4T5 ■

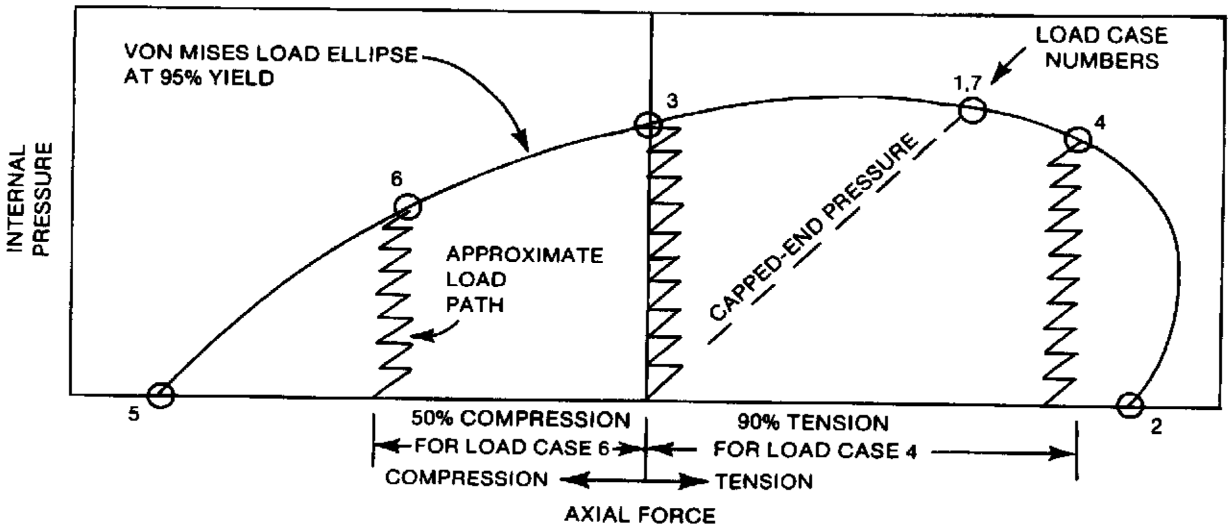


Figure 28—Test 4.3.9 Strain Gauges Specimens with Internal Pressure and Tension and Compression

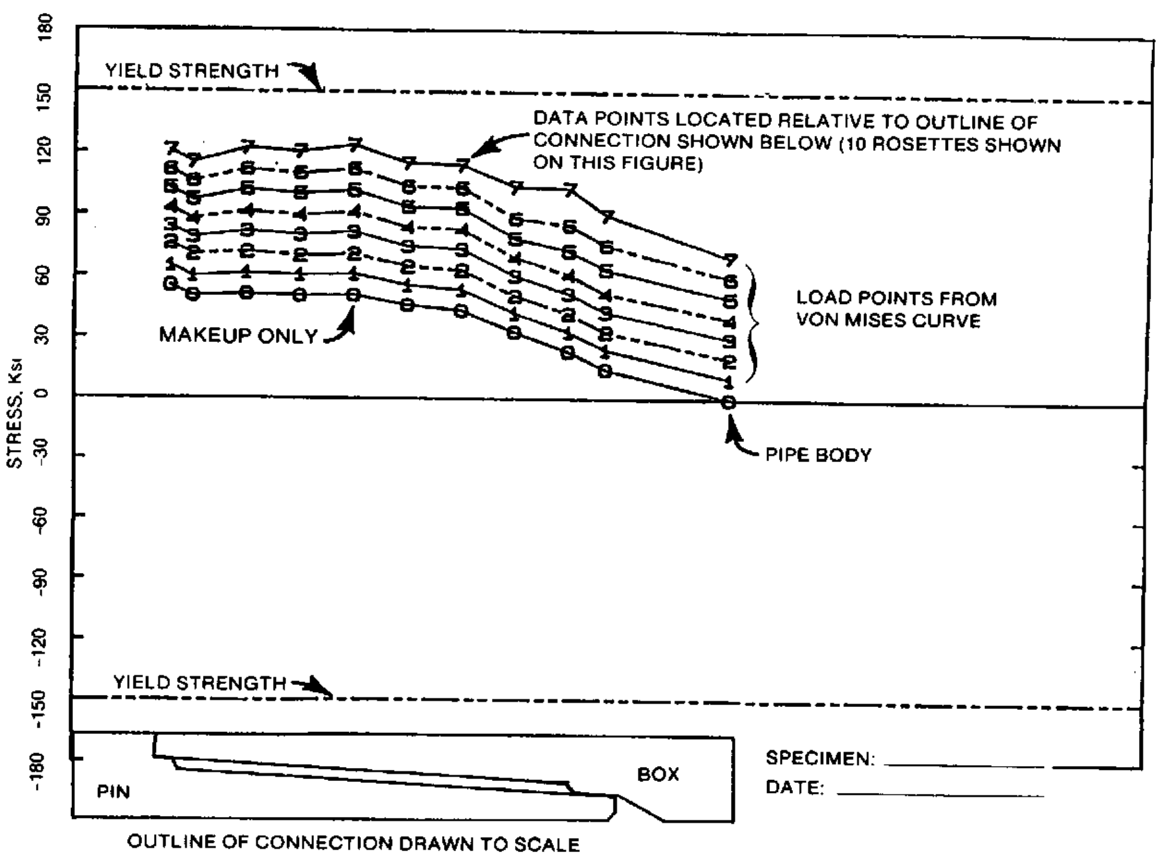
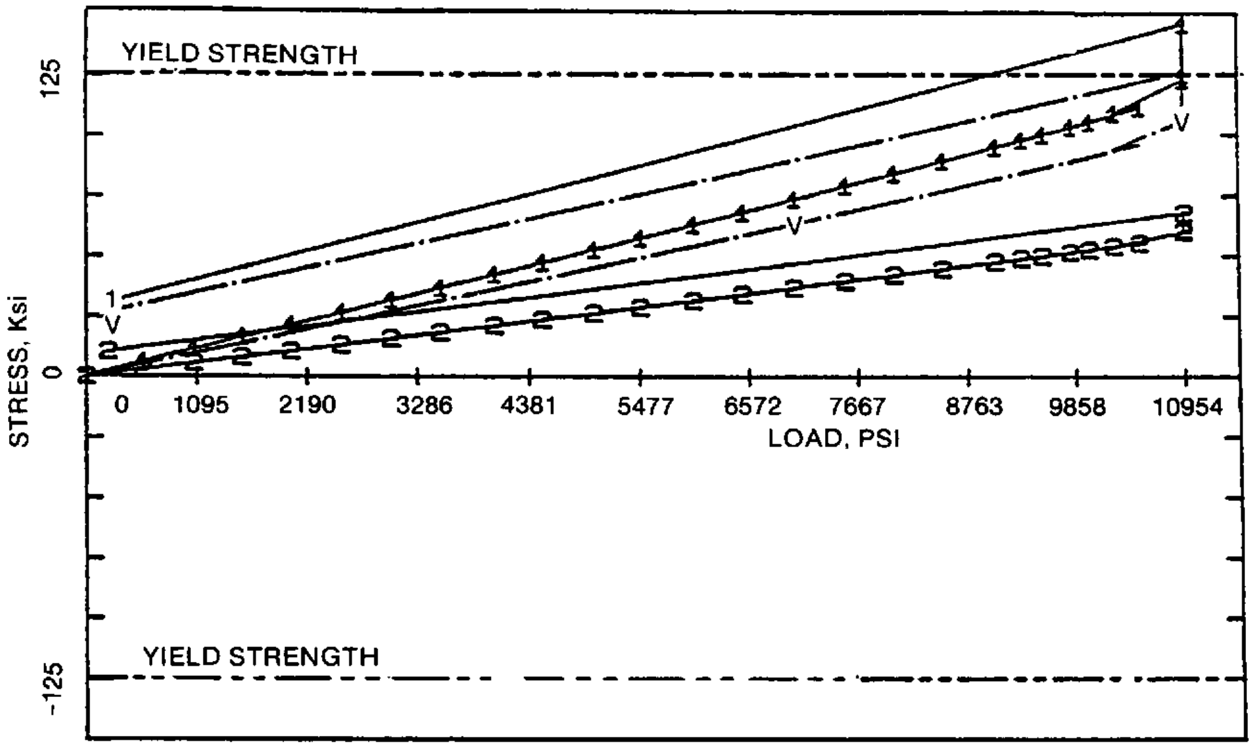


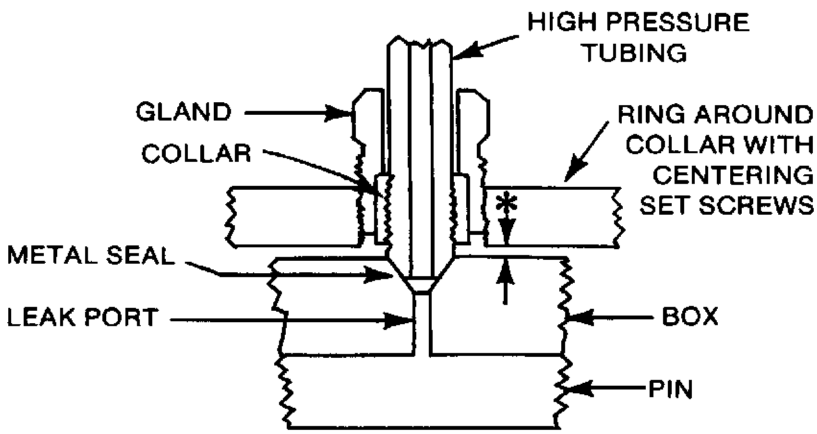
Figure 29—Example Stress Distribution Plot (6 Sheets to be Provided)

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000



NOTES:
——1 = AXIAL STRESS
——2 = CIRCUMFERENTIAL STRESS
—·—V = VON MISES STRESS
—NUMBERS "1" AND "2" ARE ACTUAL DATA POINTS
—START PLOT WITH VALUE OF MAKEUP STRESS AT ZERO LOAD (NONE SHOWN IN THIS EXAMPLE).

Figure 30—Example Stress Versus Load Plot



* 1/16" Minimum Diametrical Clearance to Box

Figure 31—Ring/Gland Port

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

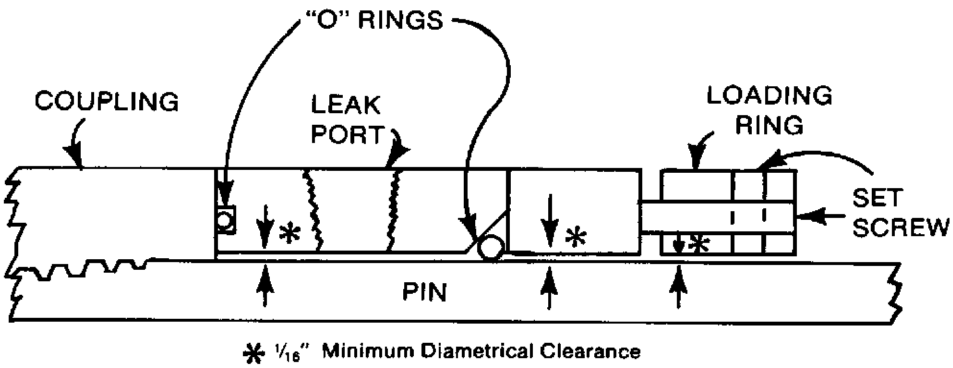


Figure 32—Leak Trap Device

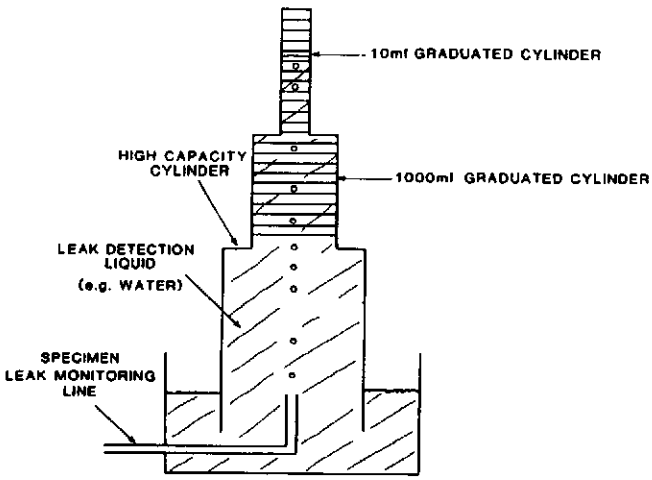


Figure 33—Leakage Measuring System

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

APPENDIX A—DETERMINATION OF TEST PRESSURE AND TEMPERATURE

The following equations are intended for use in this connection evaluation program and may not be appropriate for casing and tubing string design. Alternate procedures to address connection derating due to pressure and/or tension may be used but must be documented in the summary report. Use Data Sheet B-7 to calculate the test loads.

For the purposes of Equations A-1–A-9, the following apply:

Where:

A_i = 0.7854 (D-2t_s)2
A_o = 0.7854 D^2
A_p = 3.1416 (D-t)t
D = Specified pipe outside diameter.
DL = Effective dogleg severity in degrees/100 feet.
F_y = Published joint strength of the connection when the joint strength is the yield load of the connection.
F_t = Published joint strength of the connection when the joint strength is the parting or failure load of the connection.
K_{pe} = Pressure efficiency constant of the connection.
K_{te} = Tension efficiency constant of the connection.
P_c = API collapse rating for specified wall thickness and actual specimen yield strength.
P_i = Internal test pressure.
P_o = External test pressure.
P_{iyp} = Internal yield pressure for the pipe body as calculated by the applicable equation in API Bulletin 5C3.
P_{ipr} = Internal pressure resistance of the threaded product.
P_y = Maximum pressure for an internal fiber stress.
S_y = 100 percent of minimum of the average specimen yield strength (measured at room temperature or at user temperature) for a pipe member in a set (pin or box member for an integral connection).
S_{yt} = 95 percent of S_y for room temperature capped-end proof tests. 90 percent of S_y for user temperature capped-end proof tests. 100 percent of S_y for combined load proof tests.
S_t = 100 percent of minimum of the average specimen tensile strength (measured at room temperature or at user temperature) for a pipe member in a set (pin or box member for an integral connection).
t = Specified wall thickness.
t_s = Minimum wall thickness for all specimen pipes in a set (however, the wall thickness used in the calculations shall not be greater than the specified wall thickness for the pipe being tested).
T = Total axial load.
T_y = Connection axial load for yield.

1. User Pressure

User pressure = Maximum anticipated service pressure (A-l)

The user pressure shall not exceed the manufacturer's internal pressure resistance rating for the connection, or 95 percent of ID yield (see Equation A-4) at room temperature, or 90 percent of ID yield at user temperature (Classes I, II, or III only). When no user pressure is specified, the user pressure selected by the manufacturer shall not be less than 60 percent of ID yield.

2. User Temperature

User temperature = Maximum anticipated service temperature + 25°F (A-2)

The user temperature shall not be less than 325°F.

3. Connection Axial Load for Yield

$$T_y = S_y K_{te} (A_o - A_i) \quad \text{(A-3)}$$

a. For connections with a tension efficiency of 100 percent or greater.

$$K_{te} = 1.00$$

b. For connections with a tension efficiency that is less than 100 percent.

1. If the joint strength is the load at yield of the connection.

$$K_{te} = \frac{F_y}{A_p S_y}$$

2. If the joint strength is the parting or failure load of the connection.

$$K_{te} = \frac{F_t}{A_p S_t}$$

4. Connection Internal Test Procedure

$$P_y = \frac{S_{yt} K_{pe} (A_o - A_i)}{1.7321 A_o}$$

a. For connections with a pressure efficiency of 100 percent or greater.

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

$$K_{pe} = 1.00$$

b. For connections with a pressure efficiency which is less than 100%.

$$K_{pe} = \frac{P_{ipr}}{P_{iyp}}$$

5. Combined Internal Pressure and Axial Load Test

$$\left[\frac{P_i}{P_y}\right]^2 + \left[\frac{T}{T_y} - \frac{P_i}{P_y}\frac{(1\text{-}2\ t_s/D)^2}{1.7321}\right]^2 = (.95)^2 \qquad \text{(A-5)}$$

Equation A-5 can be evaluated or the factor P_i/P_y can be determined by locating the value shown on Table 17 where the t_s/D ratio and the T/T_y value intersect. Multiplying P_i/P_y by P_y determined in Equation A-4 (using 100 percent of S_y for S_{yt}) gives the test pressure. Multiplying T/T_y by T_y determined in Equation A-3 gives the total axial load, T, to be applied. The machine load to be applied in the test is the total axial load, T, adjusted for any pressure induced axial load.

6. External Test Pressure

$$P_o = \text{Pressure as specified below:} \qquad \text{(A-6)}$$

The external test pressure, P_o, is equal to the collapse pressure of the pipe calculated with the equations in Section 1 of API Bulletin 5C3 using the average specimen yield strength instead of the specified yield strength. The machine load to be applied in the test is the total axial load, T, adjusted for any pressure-produced axial load.

For connections with an external pressure efficiency that is less than 100 percent of the pipe collapse, the external test pressures adjusted for axial load as specified in API Bulletin 5C3 shall be reduced to the external efficiency rating specified by the manufacturer.

7. Thermal Cycling Tests With Tension and Pressure

a. $T = 0.8\, T_y$ (A-7)

Where:

T_y is as defined in Equation A-3 using yield strength measured at the user temperature.

b. The pressure used shall result in an equivalent stress of 90 percent of the minimum yield strength measured at user temperature in specimen set X. It is determined as follows:

$$P_i = P_y \left[\frac{b + (b^2 + .68a)^{0.5}}{2a}\right] \qquad \text{(A-8)}$$

Where:

$$a = 1 + \frac{(1\text{-}2\ t_s/D)^4}{3}$$

$$b = 0.924\ (1\text{-}2\ t_s/D)^2$$

P_y is determined from Equation A-4 where S_{yt} is 100 percent of the minimum yield strength measured at user temperature in specimen set X.

Equation A-8 can be evaluated or the factor P_i/P_y can be determined by locating the value shown in Table 18 for the t_s/D ratio of interest.

8. Effective Dogleg Severity

$$DL = \text{Differential Bending Stress}/(218\ D) \qquad \text{(A-9)}$$

Note: D must be in inches and stress must be in psi for the constant of 218 shown.

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

APPENDIX B—DATA SHEETS

Appendix B contains data sheets for reporting actual test data.

If the data is inserted by hand, use 11 x 17 inch data sheets to report actual test data. It is permissible to use enlarged reproduced copies of the data sheets in this document. If the data sheets are filled out by typed print or spreadsheet, then 9.5 × 11 inch data sheets may be used to report the data, provided the same format is used and all data is clearly legible. The use of SI units is permissible provided the data sheets are modified to show the appropriate units.

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

B-1—Load Frame Calibration Data Sheet

PAGE 1 OF ______ PAGES

CALIBRATION NO. ________

CALIBRATION PARAMETERS: SPECIMEN TYPE (ROUND BAR OR TUBULAR) ____________________

NOMINAL OD (IN.) ________ NOMINAL WALL THICKNESS (IN.) ________ GRADE ________ SPECIMEN HEAT LOT NO. ________

CALIBRATION FOR FOLLOWING CONNECTION TESTS (DESCRIPTIONS/NO.'S) ____________________

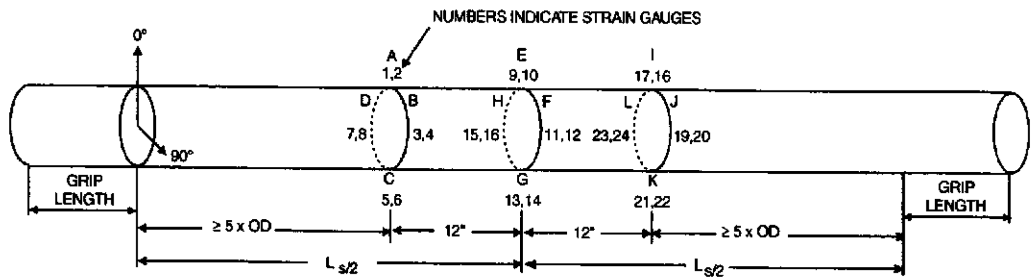
____

____

TEST SITE ________ DATE (S) ________ TEST MACHINE ________

CONNECTION MANUFACTURER ____________________

MEASURED .2% OFF SET YIELD STRESS (KSI) ______ MEASURED ULTIMATE STRESS (KSI) ______ MEASURED YOUNGS MODULUS (KSI) ______ MEASURED TEST TEMP(°F) ______ SPECIMEN SIZE ______



L_S = ________

SPECIMEN GEOMETRY:

OUTER DIAMETER (IN.)						THICKNESS, IF TUBULAR TYPE SPECIMEN (IN.)											
A-C	B-D	E-G	F-H	I-K	J-L	A	B	C	D	E	F	G	H	I	J	K	L

COMMENTS: ____________________

____

____

____

____

____

____

____

DATA RECORDED BY ____________________ DATE ________

DATA WITNESSED BY ____________________ DATE ________

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

B-1—Load Frame Calibration Data Sheet (Continued)

Page ______ of ______ Pages

Calibration No. ____________

Test Date (s) ____________

STRAIN GAUGE DATA

STRAIN AT LOCATION (ODD NUMBERS - AXIAL STRAIN, EVEN NUMBERS - HOOP STRAIN)												MACHINE LOAD (KIPS)	PRESSURE (KSI)	TOTAL LOAD (KIPS)
1 / 2	3 / 4	5 / 6	7 / 8	9 / 10	11 / 12	13 / 14	15 / 16	17 / 18	19 / 20	21 / 22	23 / 24			

DATA RECORDED BY ______________________________ DATE ______________

DATA WITNESSED BY ______________________________ DATE ______________

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

B-2—Material Property Data Sheet

SPECIMEN SET LETTER ______ COUPLING NO. ______ TO ______ PIN A NO. ______ TO ______ PIN B NO. ______ TO ______

CONNECTION MANUFACTURER ______ CONNECTION TYPE ______ STEEL MANUFACTURER ______

TENSILE TEST PERFORMER ______ DATE (S) ______ LOCATION ______

TENSILE TEST MACHINE TYPE ______ METHOD OF CONTROL ______

STRAIN MEASUREMENT METHOD ______ NOMINAL OD (IN.) ______ NOMINAL WALL THICKNESS (IN.) ______ GRADE ______

CHEMICAL CONSTITUENTS %	C	Si	Mn	Cr	Mo	Nb	Ti	Al	P	S	B	Ni
COUPLING MOTHER JOINT CHEMISTRY												
PIN A MOTHER JOINT CHEMISTRY												
PIN B MOTHER JOINT CHEMISTRY												

	LOCATION	HEAT NUMBER	JOINT NUMBER	COUPON	YIELD STRENGTH (KSI) PER API *	YIELD STRENGTH (KSI) 0.2% OFFSET	ULTIMATE STRESS (KSI)	ELONGATION* (%)	YOUNG'S MODULUS (KSI)	TEST TEMP (°F)
Room Temperature	PIN A MOTHER JOINT			End 1						
				End 2						
				Middle						
				Average						
	PIN B MOTHER JOINT			End 1						
				End 2						
				Middle						
				Average						
	COUPLING MOTHER JOINT			End 1						
				End 2						
				Middle						
				Average						
Elevated Temp.	PIN A MOTHER JOINT *									
	PIN B MOTHER JOINT *									
	COUPLING MOTHER JOINT *									

*As Specified by Section 5.3.

TEST COUPON SKETCH: W/NOMINAL DIMENSIONS

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

B-3—Specimen Geometry Data Sheet

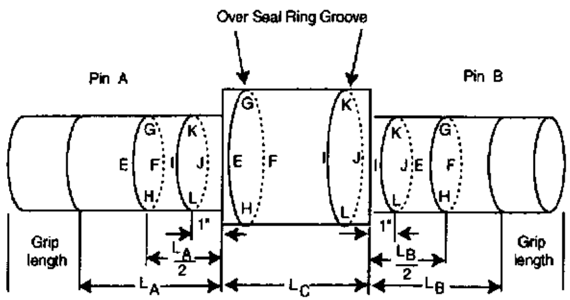
SPECIMEN SET LETTER ____________ COUPLING (BOX) NO. ____________ PIN A NO. ____________ PIN B NO. ____________

NOMINAL OD (IN.) ____________ NOMINAL WALL THICKNESS (IN.) ____________ GRADE ____________

CONNECTION MANUFACTURER ____________ CONN. TYPE ____________ DRAWING NO. ____________ REV. NO. ____________ REV. DATE ____________

MOTHER JOINT NO.: COUPLING ____________ PIN A ____________ PIN B ____________

FRONT SEAL TYPE (METAL, RESILIENT, OR THREADS) ____________ REAR SEAL TYPE (METAL, RESILIENT, OR THREADS) ____________



L_A = ____________ IN.
L_B = ____________ IN. (Length Coupling, Upset, or Box for Integral Connections)
L_C = ____________ IN.

		BOX	PIN A	PIN B
OUTER DIAMETER (IN.)	E - F			
	G - H			
	I - J			
	K - L			
WALL THICKNESS (IN.)	E	—		
	F	—		
	G	—		
	H	—		
	I	—		
	J	—		
	K	—		
	L	—		

	END A					END B				
	AS * MACHINED		AFTER INITIAL BREAK OUT (4.2.1.c)	AFTER THIRD BREAK OUT (4.2.2.b)	AFTER NINTH BREAK OUT (4.2.2.b)	AS * MACHINED		AFTER INITIAL BREAK OUT (4.2.1.c)	AFTER THIRD BREAK OUT (4.2.2.b)	AFTER NINTH BREAK OUT (4.2.2.b)
	IN	OUT				IN	OUT			
DATE										
PIN METAL SEAL APEX DIAMETER										
BOX METAL SEAL APEX DIAMETER										
METAL SEAL INTERFERENCE (DIA)										
RING GROOVE DIAMETER										
RING GROOVE WIDTH		–	—	—			–	—	—	
RING GROOVE LOCATION		–	—	—			–	—	—	
RING GAUGE STAND OFF (BYE)			—	—				—	—	
PLUG GAUGE STAND OFF (BYE)			—	—				—	—	
THREAD INTERFERENCE (CLEARANCE)			—	—				—	—	
PIN TAPER (IN/IN)			—	—				—	—	
BOX TAPER (IN/IN)			—	—				—	—	
PIN LEAD ERROR (IN/IN)		–	—	—			–	—	—	
BOX LEAD ERROR (IN/IN)		–	—	—			–	—	—	
PIN METAL SEAL OVALITY	–					–				
BOX METAL SEALOVALITY	–					–				

DATA RECORDED BY ____________ DATE ____________

DATA WITNESSED BY ____________ DATE ____________

* Before plating or coating or any other surface treatment

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

B-4—Specimen Make Up/Breakout Data Sheet

Page 1 of ______ Pages
Test 4.2.1 and 4.2.2

SPECIMEN SET LETTER ____________ COUPLING (BOX) NO. ____________ PIN A NO. ____________ PIN B NO. ____________

NOMINAL OD (IN.) ____________ NOMINAL WALL THICKNESS (IN.) ____________ GRADE ____________

CONNECTION MANUFACTURER ____________ CONNECTION TYPE ____________ DRAWING NO. ____________ REV. NO. ____________ REV. DATE ____________

MAKE UP SITE ____________ DATE(S) ____________ MAKE UP MACHINE ____________

ANTI - GALLING TREATMENT, BOX ____________ PIN ____________

THREAD LUBRICANT MANUFACTURER ____________ TYPE ____________ PRODUCT NO. ____________

SEAL RING MATERIAL ____________ SEAL RING DRAWING NO. ____________ REV. NO. ____________ REV. DATE ____________

REFERENCE TORQUE FOR TORQUE VS. MAKE UP POSITION PLOT (FT-LB) ____________

TEST NO.	MAKE UP NO.	PIN	BOX	WEIGHT OF LUBRICANT (GRAMS)	SEAL RING WIDTH (IN.)	SEAL RING THICKNESS (IN.)	SEAL RING WEIGHT (GRAMS)	PLANNED MAKE UP TORQUE (FT - LBS)	SHOULDER TORQUE (FT - LBS)	TURNS TO SHOULDER	TOTAL TORQUE (FT - LBS)	TOTAL TURNS	MAKE UP SPEED (RPM)	FINAL PORT TRANSDUCER PRESSURE (KSI)	WAIT TIME	BREAK OUT TORQUE (FT - LBS)	REFURBISHING AND GALLING OBSERVATIONS
4. 2. 1		A	A											—			
		B	B											—			
		A	B														
		B	A														
		A	A														
		B	B														
4. 2. 2		A	A														
		B	B														
		A	B	—										—			
		B	A	—										—			

DATA RECORDED BY ____________ DATE ____________

DATA WITNESSED BY ____________ DATE ____________

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

B-4—Specimen Make Up/Break Out Data Sheet (Continued)

Page ________ of ________ Pages

TEST NO.	MAKE UP NO.	PIN	BOX	WEIGHT OF LUBRICANT (GRAMS)	SEAL RING WIDTH (IN.)	SEAL RING THICKNESS (IN.)	SEAL RING WEIGHT (GRAMS)	PLANNED MAKE UP TORQUE (FT - LBS)	SHOULDER TORQUE (FT - LBS)	TURNS TO SHOULDER	TOTAL TORQUE (FT - LBS)	TOTAL TURNS	MAKE UP SPEED (RPM)	FINAL PORT TRANSDUCER PRESSURE (KSI)	WAIT TIME	BREAK OUT TORQUE (FT - LBS)	REFURBISHING AND GALLING OBSERVATIONS
4.2.2 (CONT'D)	3	A	A	—										—			
		B	B	—										—			
	4	A	B	—										—			
		B	A	—										—			
	5	A	A	—										—			
		B	B	—										—			
	6	A	B	—										—			
		B	A	—										—			
	7	A	A														
		B	B														
		A	A														
		B	B														
		A	B														
		B	A														
		A	A														
		B	B														

DATA RECORDED BY ________________________ DATE ____________

DATA WITNESSED BY ________________________ DATE ____________

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

B-5—Sealing Proof Test Data Sheet

TEST DESCRIPTION ______________________ TEST NO. __________

NOMINAL OD (IN.) __________ NOMINAL WALL THICKNESS (IN.) __________ GRADE __________

CONNECTION MANUFACTURER __________ CONN. TYPE __________ DRAWING NO. __________ REV. NO __________ REV. DATE __________

TEST SITE __________ DATE (S) __________ TEST MACHINE __________

SPECIMEN SET LETTER __________ COUPLING NO. __________ PIN A NO. __________ PIN B NO. __________

SPECIMEN SET LETTER __________ COUPLING NO. __________ PIN A NO. __________ PIN B NO. __________

SPECIMEN SET LETTER __________ COUPLING NO. __________ PIN A NO. __________ PIN B NO. __________

SPECIMEN SET LETTER __________ COUPLING NO. __________ PIN A NO. __________ PIN B NO. __________

SPECIMEN SET LETTER __________ COUPLING NO. __________ PIN A NO. __________ PIN B NO. __________

SPECIMEN SET LETTER __________ COUPLING NO. __________ PIN A NO. __________ PIN B NO. __________

FRONT SEAL TYPE (METAL, RESILIENT, OR THREAD) __________ METHOD OF FRONT SEAL LEAK DETECTION (Bubbles, Transducer Other) __________

REAR SEAL TYPE (METAL, RESILIENT, OR THREAD) __________ METHOD OF REAR SEAL LEAK DETECTION (Bubbles, Transducer Other) __________

INTERNAL PRESSURE MEDIUM __________ EXTERNAL PRESSURE MEDIUM __________

METHOD OF HEAT APPLICATION __________ TEST PRESSURE __________ KSI AMB. __________ KSI AT __________ °F

DATA FOR LOAD CALCULATION : OD (IN.) __________ WALL (IN.) __________ ROOM TEMP. YIELD (KSI) __________ USER TEMP. (°F) __________ YIELD (KSI) __________

DEVIATIONS TO TEST PROCEDURES: ______________________

____

____

____

DATA RECORDED BY ______________________ DATE __________

DATA WITNESSED BY ______________________ DATE __________

Note: Complete continued pages if fluid is observed exiting the monitoring line or dope pressure increases.

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

STD.API/PETRO RP 5C5-ENGL 1996 ■ 0732290 0562026 053 ■

B-5—Sealing Proof Test Data Sheet (Continued)

Page _____ of _____ Pages

NOMINAL OD (IN.) ____________ NOMINAL THICKNESS (IN.) ____________ GRADE ____________

CONNECTION MANUFACTURER ____________ CONN. TYPE ____________ DRAWING NO. ____________ REV. NO. ____________ REV. DATE ____________

NECESSARY DATA IF LEAKAGE OCCURS ____________ TEST NO. ____________ DATE ____________ SPECIMEN SET LETTER ____________

BOX NO.	PIN NO.	HOLD POINT NO.	SEAL THAT LEAKED (FRONT OR REAR)	TIME INTO HOLD	PRESSURE AT LEAK (KSI)	MACHINE LOAD AT LEAK (KIPS)	TOTAL AXIAL LOAD AT LEAK (KIPS)	INITIAL LEAK RATE		ENDING LEAK RATE		LEAK DURATION	TOTAL HOLD TIME (HR)	LEAK PORT TRANSDUCER PRESSURE (KSI)		HOLD PERIOD					
								CC / HR	BUBBLES / MIN.	CC / HR	BUBBLES / MIN			START	END	MAXIMUM TEMP. (°F)	MINIMUM TEMP. (°F)	MAXIMUM PRESSURE (KSI)	MINIMUM PRESSURE (KSI)	MAXIMUM MACHINE LOAD (KIPS)	MINIMUM MACHINE LOAD (KIPS)

DATA RECORDED BY ____________ DATE ____________

DATA WITNESSED BY ____________ DATE ____________

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

B-6—Failure Test Data Sheet

TEST DESCRIPTION ____________ TEST NO. ____________

NOMINAL OD (IN.) ____________ NOMINAL WALL THICKNESS (IN.) ____________ GRADE ____________

CONNECTION MANUFACTURER ____________ CONN. TYPE ____________ DRAWING NO. ____________ REV. NO. ____________ REV. DATE ____________

TEST SITE ____________ DATE (S) ____________ TEST MACHINE ____________

SPECIMEN SET LETTER ____________ COUPLING NO. ____________ PIN A NO. ____________ PIN B NO. ____________

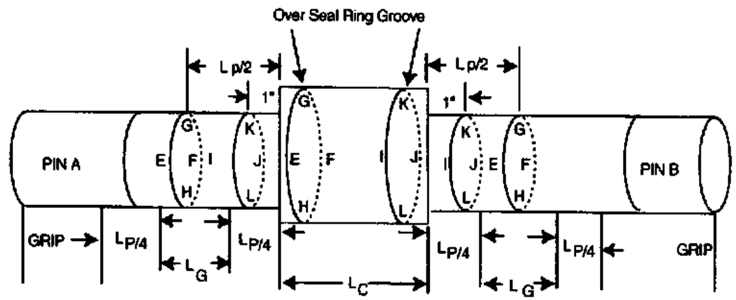
FRONT SEAL TYPE (METAL, RESILIENT, OR THREADS) ____________ REAR SEAL TYPE (METAL, RESILIENT, OR THREADS) ____________

PRESSURE MEDIUM ____________

PRESSURIZING RATE (KSI/MIN) ____________ AXIAL LOADING RATE (KIPS/MIN.) ____________

PIN A

OD	BEFORE (IN.)	AFTER (IN.)
E - F		
G - H		
I - J		
K - L		
L_G		



BOX

GAUGE LENGTH	BEFORE (IN.)	AFTER (IN.)	OD	BEFORE (IN.)	AFTER (IN.)	OD	BEFORE (IN.)	AFTER (IN.)
L_C			E - F			I - J		
			G - H			K - L		

PIN B

OD	BEFORE (IN.)	AFTER (IN.)
E - F		
G - H		
I - J		
K - L		
L_G		

AT LEAKAGE: PRESSURE (KSI) ____________ MACHINE LOAD (KIPS) ____________ TOTAL LOAD (KIPS) ____________ PIN NO. ____________

AT FAILURE: PRESSURE (KSI) ____________ MACHINE LOAD (KIPS) ____________ TOTAL LOAD (KIPS) ____________

MAXIMUM TEST PARAMETERS: PRESSURE (KSI) ____________ MACHINE LOAD (KIPS) ____________ TOTAL LOAD (KIPS) ____________

DESCRIPTION OF LOCATION/MODE OF FAILURE ; LEAKAGE RATE (CC/HR) AND OTHER COMMENT ____________

DATA RECORDED BY ____________ DATE ____________

DATA WITNESSED BY ____________ DATE ____________

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

B-7—Test Loads Calculation Sheet

Date ______________

Product: Name ____

Size ____________________ Weight ____________________ Grade ______________

Drawing No. ____________________ Revision No. ____________________ Date __________

Item	Value
1. D = Specified OD	
2. Weight (lbs. per foot)	
3. t = Specified wall thickness	
4. Minimum allowable wall, 87.5%	
5. P_{iyp}= API minimum int. yield pressure	
6. User pressure (ref. Eq. A - 1, Appendix A)	
7. $A_0 = 0.7854\ D^2$	
8. t_s = Minimum wall for set	
9. $A_i = 0.7854\ (D\text{-}2t_s)^2$	
10. A_p=3.1416 $(D\text{-}t)\ t$	
11. K_{pe}= Connection pressure efficiency	a. Internal b. External
12. P_{ipr}=Connection pressure resistance	
13. S_y = Min. ave. yield at room temp.	
14. S_{yt} = 95% S_y room temp	
15. S_y = Min. yield at user temp. of (__°F)	
16. S_{yt} = 90% S_y user temp.	
17. P_y = Room temp. test pressure	
18. P_y = User temp. test pressure	
19. $P_o = P_c$ = API collapse pressure	
20. F_y = Connection yield strength	
21. F_t = Connection parting strength	
22. K_{te} = Connection tension efficiency	
23. T_y = Connection axial yield load	
24. T = Total axial load	

All units are inches, pounds, or psi unless stated otherwise.

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

B-8—Sealing Proof Test Data Work Sheet

TEST NO. ________

Page: _____ of ___
Date: ________
By: ________

Product: Name ____________________

Nominal OD ________ Weight ________ Grade ________

Drawing: No. ________ Revision No. ________ Date ________

TEST SPECIMEN NUMBER								
PRESSURE (psi)	VOLUME (cc)	PRESSURE (psi)	VOLUME (cc)	PRESSURE (psi)	VOLUME (cc)	TIME	STEP NO.	COMMENT

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

APPENDIX C—CONTENT GUIDELINE CONNECTION EVALUATION SUMMARY REPORT

The following is intended to serve as a guide of pertinent connection evaluation data to be included in a summary report. The intent is to provide the user all the information required to purchase the connection evaluated, make it up properly, and have confidence that it will perform as desired or be aware of potential difficulties.

As the summary report references the edition of API RP 5C5 and the application, the summary report should identify deviations to the specified procedures (if any) but should not contain the detail of the test procedures that are found in this document. Also, tests not required for a test class or application should not be included or referenced.

a. General information:
1. Manufacturer.
2. Connection.
3. Class evaluated (tubing or casing) and edition of API RP 5C5.
4. OD. weight, material (if not low alloy steel), and grade.
5. Drawing no. and rev.
6. All manufacturer performance ratings, including tension. compression, internal pressure, and external pressure.

b. Introduction.
1. Statement of what was tested and that it is believed acceptable. Indicate any limitations.
2. State who executed which tests.
3. Specify what tests, if any, were omitted, why they were omitted, and why the connection should be considered adequately evaluated without the tests being completed. Deviations shall be included with the applicable procedures or tests that were followed. No comments are required if the tests were performed exactly as specified. Manufacturer derating for axial loads and internal or external pressure shall be reported.
4. Description of the connection:
   a. Thread height, pitch, load, and stab angles.
   b. Type seals (metal, resilient, and so forth).
   c. Where is the resilient seal located (for example, in the threads, against the metal seal, etc., if applicable).
   d. T&C or integral.
   e. Thread interference or clearance.
   f. Antigalling preparation.
   g. Type lubricant and makeup torque range.
5. When (year) and where the tests were performed. Personnel coordinating the tests. Who monitored the tests?

c. Specimen preparation:
1. Figure number prepared to.
2. The ratio of the material yield strength at elevated temperature/material yield strength at ambient temperature.
3. The ratio of the material ultimate strength at elevated temperature/material ultimate strength at ambient temperature.
4. Note the elevated temperature used.

d. Makeup/breakout tests:
1. Did galling occur? If so, how was it repaired? Was there a reason why galling occurred? What could have been done to minimize it?
2. Makeup speeds.
3. Reference torque, shoulder torque, total torque, turns past shoulder, and turns to full makeup.
4. Breakout torque ranges prior to pressure and temperature testing.
5. Breakout torque ranges subsequent to pressure and temperature testing.
6. Did the connection trap dope pressure?
7. Were any connections significantly over torqued and did any problems result?

e. Capped-end proof tests:
1. User pressure and temperature.
2. Maximum pressure at room temperature and at elevated temperature.
3. The test fluid used (N_2, oil, water, other).
4. How leakage was monitored.
5. Was leakage observed? If so, at what pressure, at what frequency, and what was the leak rate?
6. Which seals were tested (for example, metal seal separate from resilient seal, metal seal and resilient seal as a composite seal, and so forth)?
7. Problems encountered.

f. Combined load proof tests. For each type test (4.3.5, 4.3.6, 4.3.7, 4.3.8, and 4.3.9), provide pertinent data as shown above for the Capped-End Proof Tests. Include axial loading information.

g. Capped-end pressure to failure tests:
1. Failure location.
2. Failure pressure.
3. Leaks before failure (pressure and frequency).

h. Tension to failure tests:
1. Failure location.
2. Failure load.
3. Elongation of pipe body.
4. Dogleg equivalent based on bending stress (See Appendix A, Equation A-9).

i. Pressure with tension increasing to failure tests and compression to failure tests:

Report pertinent data similar to that reported above in capped-end proof tests and tension tests. Report each type test in a separate section.

j. Strain gauge test and data reduction

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

1. Figure showing locations and numbering of strain gauge rosettes.
2. Table 13 (four locations per connection) for each strain gauged connection.
3. Figure 29 (six sheets per specimen) for each strain gauged specimen.

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

APPENDIX D—DETAILED REPORT TO API

Only the following information shall be filed with API:

a. Summary report as outlined in Appendix C.
b. Completed data sheets, including B-7, as shown in Appendix B.
c. Required photographs.
d. Torque versus makeup position plots.
e. Strain gauge data and loads as shown in Tables 12 (15 tables per connection) for each strain gauged connection and Figures 30 (28 sheets per connection) for each strain gauged connection. All test data to be provided on floppy disk as shown on Tables 14 and15 in ASCII form.

Note: Additional original documentation such as quality assurance procedures, quality control procedures, calibration reports, certifications, contour tracings required for machine set up, strip chart recordings, etc., and actual machine drawings of the connections shall not be filed with API but shall be kept as a part of the Manufacturer's Detailed Test File.

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

APPENDIX E—EXAMPLE CALCULATIONS

The following pages provide example calculations required to perform the tests. The first example is for a connection that is rated 100 percent by the manufacturer. The second example is for a connection that is rated less than 100 percent.

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

STD·API/PETRO RP 5C5-ENGL 1996 ■ 0732290 0562034 12T ■

DATA AND TEST LOAD CALCULATION SHEET

DATA			CALCULATIONS			
Connector	:	EXAMPLE 1				
Drawing	:	A-1				
Date	:	1-Jan-88				
Grade	:	CRA-110	PB Yld Force	=	247,889 lbs	SY*Nom Ao-Ai
Min Yield	=	110,000 psi	Min Yld Press	=	18,480 psi	0.875 (2Yp t/D
Pipe OD D	=	2.875in.	Area OD Ao	=	6.4918in.^2	
Weight	=	7.70 lb/ft				
Nom Wall T	=	0.276in.	API Min Wall	=	0.242in.	0.875 * T

Minimum Walls by Sample Set			Sample Set Areas (square inches)				
Set z	Ts =	0.280in.	Area ID	Ai =	4.2091	Ao-Ai =	2.2827
Set x	Ts =	0.276in.	Area ID	Ai =	4.2383	Ao-Ai =	2.2535
Set w	Ts =	0.272in.	Area ID	Ai =	4.2675	Ao-Ai =	2.2243
Set v	Ts =	0.268in.	Area ID	Ai =	4.2969	Ao-Ai =	2.1950

Test Level	=	1
Min Press Req	=	12,000 psi
User Press	=	15,960 psi

Minimum Connection Ratings

Press Resis	=	18,480 psi	Press Efficy	=	100.0%	=	Kpe
Tensile Yld	=	247,889 lbs	Tensile Efficy	=	100.0%	=	Kte

Min. of Avg. Pipe Yld Test Data
------ at room temperature ------

Specimen Set	Min Yld St	.95*Sy Sty	Yld Press Py	Max Press 95% Py	PB Yld T Ty	Ts/D
Set z	116,000	110,200	23,550	22,370	264,790	0.097
Set x	114,000	108,300	22,850	21,700	256,900	0.096
Set w	112,000	106,400	22,160	21,050	249,120	0.095
Set v	110,000	104,500	21,470	20,400	241,450	0.093

	Py	Ty
Equations	SKpe (Ao-Ai) / [1.7321Ao]	St*Kte* (Ao-Ai)

User Temp= 325 deg F
Min. of Pipe Yld Test Data
------ at room temperature ------

Specimen Set	Min Yld St	.90*Sy Sty	Yld Press Py	Max Press 95% Py	PB Yld T Ty	Ts/D
Set z	108,000	97,200	21,920	19,730	246,500	0.097
Set x	106,000	95,400	21,240	19,120	238,900	0.096
Set w	104,000	93,600	20,570	18,520	231,300	0.095
Set v	102,000	91,800	19,910	17,920	223,900	0.093

VME Load Limit Points Determined for 95.0%
of yield (Table 19)

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

STD.API/PETRO RP 5C5-ENGL 1996 ■ 0732290 0562035 066 ■

SUMMARY OF TEST PARAMETERS
Including Temperatures and Pressures

Test 4.3.1

Initial Capped-End Pressure Cycling
at Room Temperature

Specimens Required: 1, 2, 3
Specimen Set: Z

Required for Casing Class (none)
Required for Tubing Class IV

User Pressure = 15,960 psi

Test 4.3.2

Final Capped-End Pressure Cycling
at Room Temperature

Specimens Required: 1, 2, 3
Specimen Set: Z

Required for Casing Class IV
Required for Tubing Class IV

Ao = 6.4918 square inches
Ao-Ai = 2.2827 square inches
User Pressure = 15,960 psi

Max pressure is based on 95% of room temperature yield.

Sy = 116,000 psi at room temperature
Syt = 110,200 psi Sy * .95
Max Press Py = 22,370 psi Syt Kpe (Ao-Ai) / 1.7321 Ao

Test 4.3.3

Initial Capped-End Pressure Cycling
with Thermal Cycling

Specimens Required: 1, 2, 3, 4, 5, 6
Specimen Set: Z

Required for Casing Class (none)
Required for Tubing Class I, II, III

User Pressure = 15,960 psi
User Temp = 325 deg F

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

Test 4.3.4

Final Capped-End Pressure Cycling
with Thermal Cycling

Specimens Required:	1, 2, 3, 4, 5, 6	Required for Casing Class I, II, III
Specimen Set:	Z	Required for Tubing Class I, II, III

Ao = 6.4918 square inches
Ao-Ai = 2.2827 square inches

Calculated Test Parameters
------ at user temperature ------

User Temp = 325 deg F
User Pressure = 15,960 psi

Max pressure is based on 90% of user temperature yield.

Sy	=	108,000 psi at user temperature	
Syt	=	97,200 psi	Sy * .90
Max Press Py	=	19,730 psi	Syt Kpe (Ao-Ai) / 1.7321 Ao

Calculated Test Parameters
------ at room temperature ------

Max pressure is based on 95% of room temperature yield.

Sy	=	116,000 psi at room temperature	
Syt	=	110,200 psi	Sy * .95
Max Press Py	=	22,370 psi	Syt Kpe (Ao-Ai) / 1.7321 Ao

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

Test 4.3.5

Compression and Internal Pressure
at Room Temperature

Specimens Required: 1, 2, 3 — Required for Casing Class I
Specimen Set: V — Required for Tubing Class I

Ao = 6.4918 square inches
Ai = 4.2969 square inches
Ao-Ai = 2.1950 square inches

For a Yield of 110,000 psi at room temperature:
Yld Load (Ty) = 241,450 lbs   Sy * Kte * (Ao-Ai)

Yield Pressure Calculated at Room Temperature

Sy = 110,000 psi at room temperature
Yld Press Py = 21,470 psi   Syt Kpe (Ao-Ai) / 1.7321 Ao
ts/D = 0.093

Load Points From Table 19

T/Ty	=	-0.400	-0.200	0.000
P/Py	=	0.683	0.803	0.887

--------- Figure 20 Load Limits ---------

Load Point	T/Ty Fig 20	Total Load Pi/Py Table 19	Machine T lbs	Load lbs	Pi psi	VME/VMEy
Pt1	0.00	0.000	0	0	0	0.0%
Pt2	0.00	0.887	0	(81,855)	19,050	95.0%
Pt3	-0.20	0.803	(48,290)	(122,411)	17,250	95.0%
Pt4	-0.40	0.683	(96,580)	(159,529)	14,650	95.0%
Pt5	-0.40	0.000	(96,580)	(96,580)	0	40.0%

(compressive load)

Test 4.3.5

Compression and External Pressure
at room temperature

D/Ts = 10.73

--------- Figure 21 Load Limits ---------

Load Point	T/Ty Fig 21	Tot Load T lbs	Equiv Yield Ypa API5C3 1.1.5.1	Machine Load lbs	API 5C3 Po psi	Load Point
Pt1	0.00	0	110,000	0	0	Pt1
Pt2	0.00	0	110,000	0	18,600	Pt2
Pt3	-0.20	(48,290)	119,338	(48,290)	20,170	Pt3
Pt4	-0.40	(96,580)	125,189	(96,580)	21,160	Pt4
Pt5	-0.40	(96,580)	125,189	(96,580)	0	Pt5

(compressive load)

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

Test 4.3.6

Thermal Cycling Tests
with Tension and Internal Pressure

Specimens Required:	1, 2, 3, 4, 5, 6	Required for Casing Class (none)
Specimen Set:	X	Required for Tubing Class I

User Temp	=	325 deg F
Ao	=	6.4918 square inches
Ai	=	4.2383 square inches
Ao-Ai	=	2.2535 square inches

Tension load for test is based on 80% of user temp yield.

Sy	=	106,000 psi at user temperature	
Syt	=	84,800 psi	Sy * .80
Test Load (T)	=	191,100 lbs	Syt * Kte * (Ao-Ai)

Yield pressure is calculated for 100% of user temp yield.

Syt	=	106,000 psi at user temperature	
Py	=	21,240 psi	Sy Kpe (Ao-Ai) / 1.7321 Ao

Internal test pressure is calculated for 90% of equivalent yield.

Ts/D	=	0.096000
1-2Ts/D	=	0.808000

From Appendix A, Equations A-B and/or Table 20

a = 1.142077	1 + [(1-2Ts/D)^4 / 3]
b = 0.603246	0.924 (1-2Ts/D)^2
Test Press Pi = 15,540 psi	Py [(b + (b^2+.68a) ^.5) / 2a]

VME/VMEy = 90.0%

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

Test 4.3.7

Tension and Internal Pressure Load Limits
at Room Temperature

Specimens Required: I:1-6 II:1-3 — Required for Casing Class I, II
Specimen Set: X — Required for Tubing Class (none)

Ao = 6.4918 square inches
Ai = 4.2383 square inches
Ao-Ai = 2.2535 square inches

Yield Pressure Calculated at Room Temperature

Sy = 114,000 psi at room temperature
Yld Press Py = 22,850 psi Syt Kpe (Ao-Ai) / 1.7321 Ao

For a yield of 114,000 psi at room temperature:
Yld Load (Ty) = 256,900 lbs Sy * Kte * (Ao-Ai)
ts/D = 0.096

Load Points From Table 19

T/Ty	=	0.600	0.850	0.950
P/Py	=	0.915	0.767	0.627

--------- Figure 24 Load Limits ---------

Load Point	T/Ty Fig 24	Pi/Py Table 19	Total Load T lbs	Machine Load lbs	Pi psi	VME/VMEy
Pt1	0.00	0.000	0	0	0	0.0%
Pt2	0.95	0.000	244,055	244,055	0	95.0%
Pt3	0.95	0.627	244,055	183,321	14,330	95.0%
Pt4	0.85	0.767	218,365	144,111	17,520	95.0%
Pt5	0.60	0.915	154,140	65,518	20,910	95.0%
Pt6	0.36	0.950	92,013	0	21,710	95.0%

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

Test 4.3.8

Tension and External Pressure Load Limits
at Room Temperature

Specimens Required: I:1-6 II:1-3 Required for Casing Class (none)
Specimen Set: X Required for Tubing Class I, II

Ao = 6.4918 square inches
Ai = 4.2383 square inches
Ao-Ai = 2.2535 square inches

Yield Pressure Calculated at Room Temperature

Sy = 114,000 psi at room temperature
Yld Press Py = 22,850 psi Sy Kpe (Ao-Ai) / 1.7321 Ao

For a yield of 114,000 psi at room temperature:
Yld Load (Ty) = 256,900 lbs Sy * Kte * (Ao-Ai)
D/Ts = 10.42

--------- Figure 26 Load Limits ---------

Load Point	T/Ty Fig 26	Total Load T lbs	Equiv Yield Ypa API 5C3 1.1.5.1	Machine Load lbs	API 5C3 Po psi	Load Point
Pt1	0.00	0	114,000	0	0	Pt1
Pt2	0.00	0	114,000	0	19,270	Pt2
Pt3	0.40	102,760	84,140	102,760	14,600	Pt3
Pt4	0.80	205,520	36,600	205,520	6,350	Pt4
Pt5	0.80	205,520	36,600	205,520	0	Pt5

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

Test 4.3.9

Strain Gauged Internal Pressure Tests
with Tension and Compression
at Room Temperature

Specimens Required	: 1, 2	Coupled	Required for Casing Class I
	: 1, 2, 3	Integral	Required for Casing Class I
Figure 2	: 1, 3		
Figure 3	: 1, 3, 4		
Figure 4	: 1, 3		
Figure 5	: 1, 3, 4		

Specimen Set : W

Ao	=	6.4918 square inches
Ai	=	4.2675 square inches
Ao-Ai	=	2.2243 square inches

For a yield of 114,000 psi at room temperature:

Yld Load (Ty)	=	249,120 lbs	Sy * Kte * (Ao-Ai)
Yld Press Py	=	22,160 psi	Sy Kpe (Ao-Ai) / 1.7321 Ao
95% Py	=	21,050 psi	Syt Kpe (Ao-Ai) / 1.7321 Ao
Ts/D	=	0.095	

Load Points From Table 19

T/Ty	=	-0.500	0.000	0.900
P/Py	=	0.607	0.888	0.711

--------- Figure 28 Load Limits ---------

Load Point	T/Ty Fig 28	Pi/Py Table 19	Total Load T lbs	Machine Load lbs	Pi psi	VME/VMEy
Pt1	0.36	0.950	89,831	0	21,050	95.0%
Pt2	0.95	0.000	236,664	236,664	0	95.0%
Pt3	0.00	0.888	0	(83,985)	19,680	95.0%
Pt4	0.90	0.711	224,208	156,995	15,750	95.0%
Pt5	-0.95	0.000	(236,664)	(236,664)	0	95.0%
Pt6	-0.50	0.607	(124,560)	(182,001)	13,460	95.0%
Pt7	0.36	0.950	89,831	0	21,050	95.0%

(compressive load)

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

STD·API/PETRO RP 5C5-ENGL 1996 ■ 0732290 0562042 2T6 ■

DATA AND TEST LOAD CALCULATION SHEET

DATA			CALCULATIONS			
Connector	:	EXAMPLE 2				
Drawing	:	A-1				
Date	:	1-Jan-88				
Grade	:	CRA-110	PB Yld Force	=	247,889 lbs	SY*Nom Ao-Ai
Min Yield	=	110,000 psi	Min Yld Press	=	18,480 psi	0.875 (2Yp t/D)
Pipe OD D	=	2.875 in.	Area OD Ao	=	6.4918 in.^2	
Weight	=	7.70 lb/ft				
Nom Wall T	=	0.276 in.	API Min Wall	=	0.242 in.	0.875 * T

Minimum Walls by Sample Set			Sample Set Areas (square inches)				
Set Z	Ts =	0.280 in.	Area ID	Ai =	4.2091	Ao-Ai =	2.2827
Set X	Ts =	0.276 in.	Area ID	Ai =	4.2383	Ao-Ai =	2.2535
Set W	Ts =	0.272 in.	Area ID	Ai =	4.2675	Ao-Ai =	2.2243
Set V	Ts =	0.268 in.	Area ID	Ai =	4.2969	Ao-Ai =	2.1950

Test Level = 1
Min Press Req = 12,000 psi
User Press = 15,960 psi

Minimum Connection Ratings

Press Resis	=	17,002 psi	Press Efficy	=	92.0%	=	Kpe
Tensile Yld	=	213,185 lbs	Tensile Efficy	=	86.0%	=	Kte

Min. of Avg. Pipe Yld Test Data
------ at room temperature ------

Specimen Set	Min Yld St	.95*Sy Sty	Yld Press Py	Max Press 95% Py	PB Yld T Ty	Ts/D
Set z	116,000	110,200	21,660	20,580	227,720	0.097
Set x	114,000	108,300	21,020	19,970	220,940	0.096
Set w	112,000	106,400	20,380	19,360	214,240	0.095
Set v	110,000	104,500	19,750	18,770	207,640	0.093

	Py	Ty
Equations	SKpe (Ao-Ai) / [1.7321Ao]	St*Kte* (Ao-Ai)

User Temp= 325 deg F
Min. of Pipe Yld Test Data
------ at user temperature ------

Specimen Set	Min Yld St	.95*Sy Sty	Yld Press Py	Max Press 95% Py	PB Yld T Ty	Ts/D
Set z	108,000	97,200	20,170	18,150	212,000	0.097
Set x	106,000	95,400	19,540	17,590	205,400	0.096
Set w	104,000	93,600	18,930	17,030	198,900	0.095
Set v	102,000	91,800	18,320	16,490	192,500	0.093

VME Load Limit Points Determined for 95.0%
of yield (Table 19)

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

SUMMARY OF TEST PARAMETERS
Including Temperatures and Pressures

Test 4.3.1

Initial Capped-End Pressure Cycling
at Room Temperature

Specimens Required:	1, 2, 3	Required for Casing Class (none)
Specimen Set:	Z	Required for Tubing Class IV

User Pressure = 15,960 psi

Test 4.3.2

Final Capped-End Pressure Cycling
at Room Temperature

Specimens Required:	1, 2, 3	Required for Casing Class IV
Specimen Set:	Z	Required for Tubing Class IV

Ao	=	6.4918 square inches
Ao-Ai	=	2.2827 square inches
User Pressure	=	15,960 psi

Max pressure is based on 95% of room temperature yield.

Sy	=	116,000 psi at room temperature	
Syt	=	110,200 psi	Sy * .95
Max Press Py	=	20,580 psi	Syt Kpe (Ao-Ai) / 1.7321 Ao

Test 4.3.3

Initial Capped-End Pressure Cycling
with Thermal Cycling

Specimens Required:	1, 2, 3, 4, 5, 6	Required for Casing Class (none)
Specimen Set:	Z	Required for Tubing Class I, II, III

User Pressure = 15,960 psi
User Temp = 325 deg F

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

STD.API/PETRO RP 5C5-ENGL 1996 ■ 0732290 0562044 079 ■

Test 4.3.4

Final Capped-End Pressure Cycling
with Thermal Cycling

Specimens Required:	1, 2, 3, 4, 5, 6	Required for Casing Class I, II, III
Specimen Set:	Z	Required for Tubing Class I, II, III

Ao	=	6.4918 square inches
Ao-Ai	=	2.2827 square inches

Calculated Test Parameters
------ at user temperature ------

User Temp	=	325 deg F
User Pressure	=	15,960 psi

Max pressure is based on 90% of user temperature yield.

Sy	=	108,000 psi at user temperature	
Syt	=	97,200 psi	Sy * .90
Max Press Py	=	18,150 psi	Syt Kpe (Ao-Ai) / 1.7321 Ao

Calculated Test Parameters
------ at room temperature ------

Max pressure is based on 95% of room temperature yield.

Sy	=	116,000 psi at room temperature	
Syt	=	110,200 psi	Sy * .95
Max Press Py	=	20,580 psi	Syt Kpe (Ao-Ai) / 1.7321 Ao

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

Test 4.3.5

Compression and Internal Pressure
at Room Temperature

Specimens Required: 1, 2, 3 — Required for Casing Class I
Specimen Set: V — Required for Tubing Class I

Ao = 6.4918 square inches
Ai = 4.2969 square inches
Ao-Ai = 2.1950 square inches

For a Yield of 110,000 psi at room temperature:
Yld Load (Ty) = 207,640 lbs Sy * Kte * (Ao-Ai)

Yield Pressure Calculated at Room Temperature

Sy = 110,000 psi at room temperature
Yld Press Py = 19,750 psi Syt Kpe (Ao-Ai) / 1.7321 Ao
ts/D = 0.093

Load Points From Table 19

T/Ty =	-0.400	-0.200	0.000
P/Py =	0.683	0.803	0.887

--------- Figure 20 Load Limits ---------

Load Point	T/Ty Fig 20	Pi/Py Table 19	Total Load T lbs	Machine Load lbs	Pi psi	VME/VMEy
Pt1	0.00	0.000	0	0	0	0.0%
Pt2	0.00	0.887	0	(75,324)	17,530	95.0%
Pt3	-0.20	0.803	(41,528)	(109,719)	15,870	95.0%
Pt4	-0.40	0.683	(83,056)	(140,978)	13,480	95.0%
Pt5	-0.40	0.000	(83,056)	(83,056)	0	40.0%

(compressive load)

Test 4.3.5

Compression and External Pressure
at Room Temperature

D/Ts = 10.73

--------- Figure 21 Load Limits ---------

Load Point	T/Ty Fig 21	Tot Load T lbs	Equiv Yield Ypa API5C3 1.1.5.1	Machine Load lbs	API 5C3 Po psi	Load Point
Pt1	0.00	0	110,000	0	0	Pt1
Pt2	0.00	0	110,000	0	18,600	Pt2
Pt3	-0.20	(41,528)	118,233	(41,528)	19,990	Pt3
Pt4	-0.40	(83,056)	123,925	(83,056)	20,950	Pt4
Pt5	-0.40	(83,056)	123,925	(83,056)	0	Pt5

(compressive load)

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

Test 4.3.6

Thermal Cycling Tests
with Tension and Internal Pressure

Specimens Required:	1, 2, 3, 4, 5, 6	Required for Casing Class (none)
Specimen Set:	X	Required for Tubing Class I

User Temp	=	325 deg F
Ao	=	6.4918 square inches
Ai	=	4.2383 square inches
Ao-Ai	=	2.2535 square inches

Tension load for test is based on 80% of user temp yield.

Sy	=	106,000 psi at user temperature	
Syt	=	84,800 psi	Sy * .80
Test Load (T)	=	164,300 lbs	Syt * Kte * (Ao-Ai)

Yield pressure is calculated for 100% of user temp yield.

Syt	=	106,000 psi at user temperature	
Py	=	19,540 psi	Sy Kpe (Ao-Ai) / 1.7321 Ao

Internal test pressure is calculated for 90% of equivalent yield.

Ts/D	=	0.096000
1-2Ts/D	=	0.808000

From Appendix A, Equations A-B and/or Table 20

a = 1.142077	1 + [(1-2Ts/D)^4 / 3]
b = 0.603246	0.924 (1-2Ts/D)^2
Test Press Pi = 14,300 psi	Py [(b + (b^2+.68a) ^.5) / 2a]

VME/VMEy = 90.0%

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

Test 4.3.7

Tension and Internal Pressure Load Limits
at Room Temperature

Specimens Required: I:1-6 II:1-3 — Required for Casing Class I, II
Specimen Set: X — Required for Tubing Class (none)

Ao = 6.4918 square inches
Ai = 4.2383 square inches
Ao-Ai = 2.2535 square inches

Yield Pressure Calculated at Room Temperature

Sy = 114,000 psi at room temperature
Yld Press Py = 21,020 psi Syt Kpe (Ao-Ai) / 1.7321 Ao

For a yield of 114,000 psi at room temperature:
Yld Load (Ty) = 220,940 lbs Sy * Kte * (Ao-Ai)
ts/D = 0.096

Load Points From Table 19

T/Ty =	-0.600	-0.850	0.950
P/Py =	0.915	0.767	0.627

--------- Figure 24 Load Limits ---------

Load Point	T/Ty Fig 24	Pi/Py Table 19	Total Load T lbs	Machine Load lbs	Pi psi	VME/VMEy
Pt1	0.00	0.000	0	0	0	0.0%
Pt2	0.95	0.000	209,983	209,893	0	95.0%
Pt3	0.95	0.627	209,893	154,033	13,180	95.0%
Pt4	0.85	0.767	187,799	119,521	16,110	95.0%
Pt5	0.60	0.915	132,564	51,020	19,240	95.0%
Pt6	0.38	0.950	84,638	0	19,970	95.0%

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

Test 4.3.8

Tension and External Pressure Load Limits
at Room Temperature

Specimens Required: I:1-6 II:1-3 — Required for Casing Class (none)
Specimen Set: X — Required for Tubing Class I, II

Ao = 6.4918 square inches
Ai = 4.2383 square inches
Ao-Ai = 2.2535 square inches

Yield Pressure Calculated at Room Temperature

Sy = 114,000 psi at room temperature
Yld Press Py = 21,020 psi   Sy Kpe (Ao-Ai) / 1.7321 Ao

For a yield of 114,000 psi at room temperature:
Yld Load (Ty) = 220,940 lbs   Sy * Kte * (Ao-Ai)
D/Ts = 10.42

--------- Figure 26 Load Limits ---------

Load Point	T/Ty Fig 26	Total Load T lbs	Equiv Yield Ypa API5C3 1.1.5.1	Machine Load lbs	API 5C3 Po psi	Load Point
Pt1	0.00	0	114,000	0	0	Pt1
Pt2	0.00	0	114,000	0	19,270	Pt2
Pt3	0.40	88,380	89,220	88,380	115,480	Pt3
Pt4	0.80	176,750	52,340	176,750	9,080	Pt4
Pt5	0.80	176,750	52,340	176,750	0	Pt5

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

Test 4.3.9

Strain Gauged Internal Pressure Tests
with Tension And Compression
at Room Temperature

Specimens Required	: 1, 2	Coupled	Required for Casing Class I
	: 1, 2, 3	Integral	Required for Casing Class I
Figure 2	: 1, 3		
Figure 3	: 1, 3, 4		
Figure 4	: 1, 3		
Figure 5	: 1, 3, 4		

Specimen Set : W

Ao	=	6.4918 square inches
Ai	=	4.2675 square inches
Ao-Ai	=	2.2243 square inches

For a yield of 112,000 psi at room temperature:

Yld Load (Ty)	=	214,240 lbs	Sy * Kte * (Ao-Ai)
Yld Press Py	=	20,380 psi	Sy Kpe (Ao-Ai) / 1.7321 Ao
95% Py	=	19,360 psi	Syt Kpe (Ao-Ai) / 1.7321 Ao
Ts/D	=	0.095	

Load Points From Table 19

T/Ty	=	-0.500	-0.000	0.900
P/Py	=	0.607	0.888	0.711

--------- Figure 28 Load Limits ---------

Load Point	T/Ty Fig 28	Pi/Py Table 19	Total Load T lbs	Machine Load lbs	Pi psi	VME/VMEy
Pt1	0.39	0.950	82,619	0	19,360	95.0%
Pt2	0.95	0.000	203,528	203,528	0	95.0%
Pt3	0.00	0.888	0	(77,242)	18,100	95.0%
Pt4	0.90	0.711	192,816	130,980	14,490	95.0%
Pt5	-0.95	0.000	(203,528)	(203,528)	0	95.0%
Pt6	-0.50	0.607	(107,120)	(159,952)	12,380	95.0%
Pt7	0.39	0.950	82,619	0	19,360	95.0%

(compressive load)

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

APPENDIX F—FLOW CHART OF REQUIRED TESTS

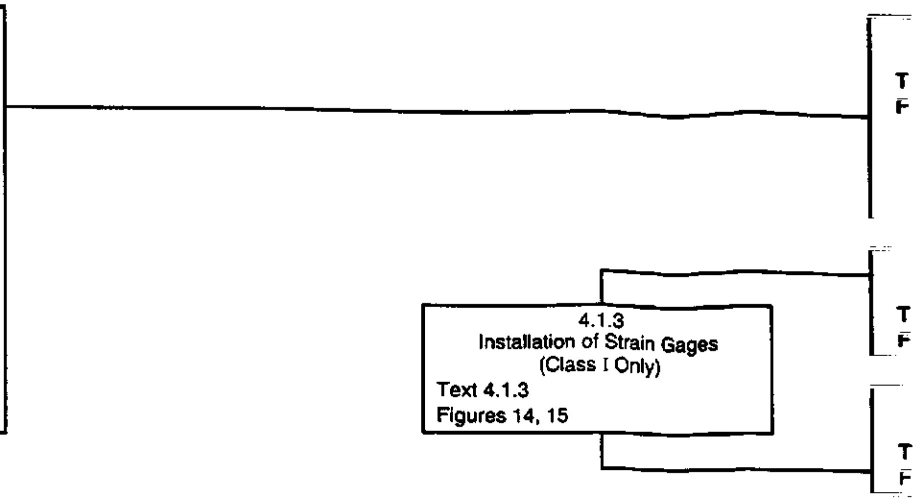
Figure F-1—Casing and Figure F-2—Tubing contain flowcharts for each of the required tests for each application of the four classes.

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

Table 1
Example Relationship Between Test Classes and Service Application [1]

Differential Working Pressure	Connector Test Classes: Production Tubulars Service Severity High	Normal	Low	Drilling Tubulars Service Severity High	Normal	Low
Over 12000 psi	I	I	II	I	II	III
8000-12000 psi	I	II	III	II	II	III
4000-8000 psi	II	III	III	III	III	IV
0-4000 psi	III	IV	IV	IV	IV	IV

[1] The values quoted for differential working pressure are intended for guidance only. It may be necessary to apply criteria other than differential working pressure such as risk, severity of service, and environmental considerations to select the class of tests appropriate for a paticular application.



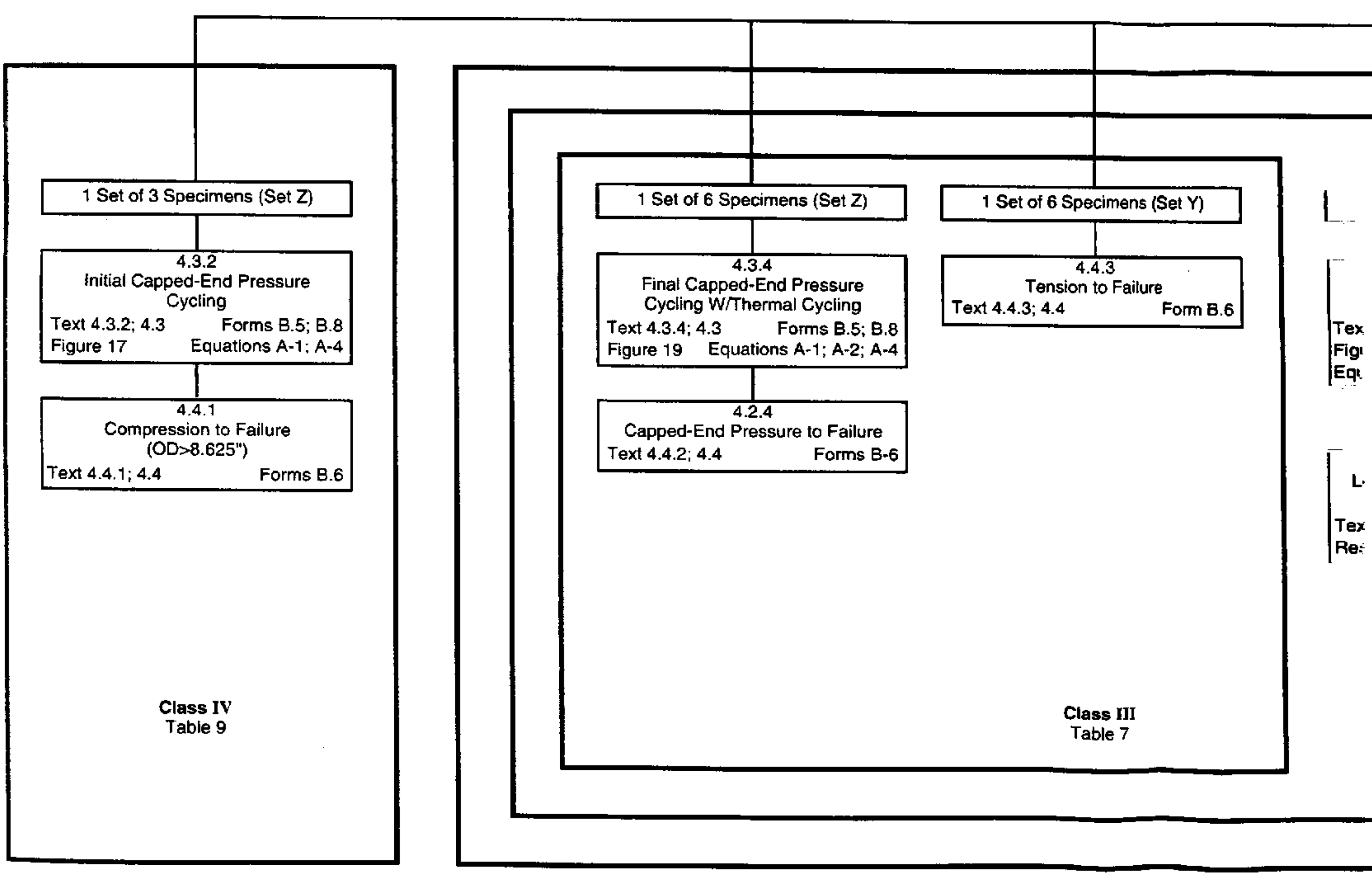


Figure F-1—Casing

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

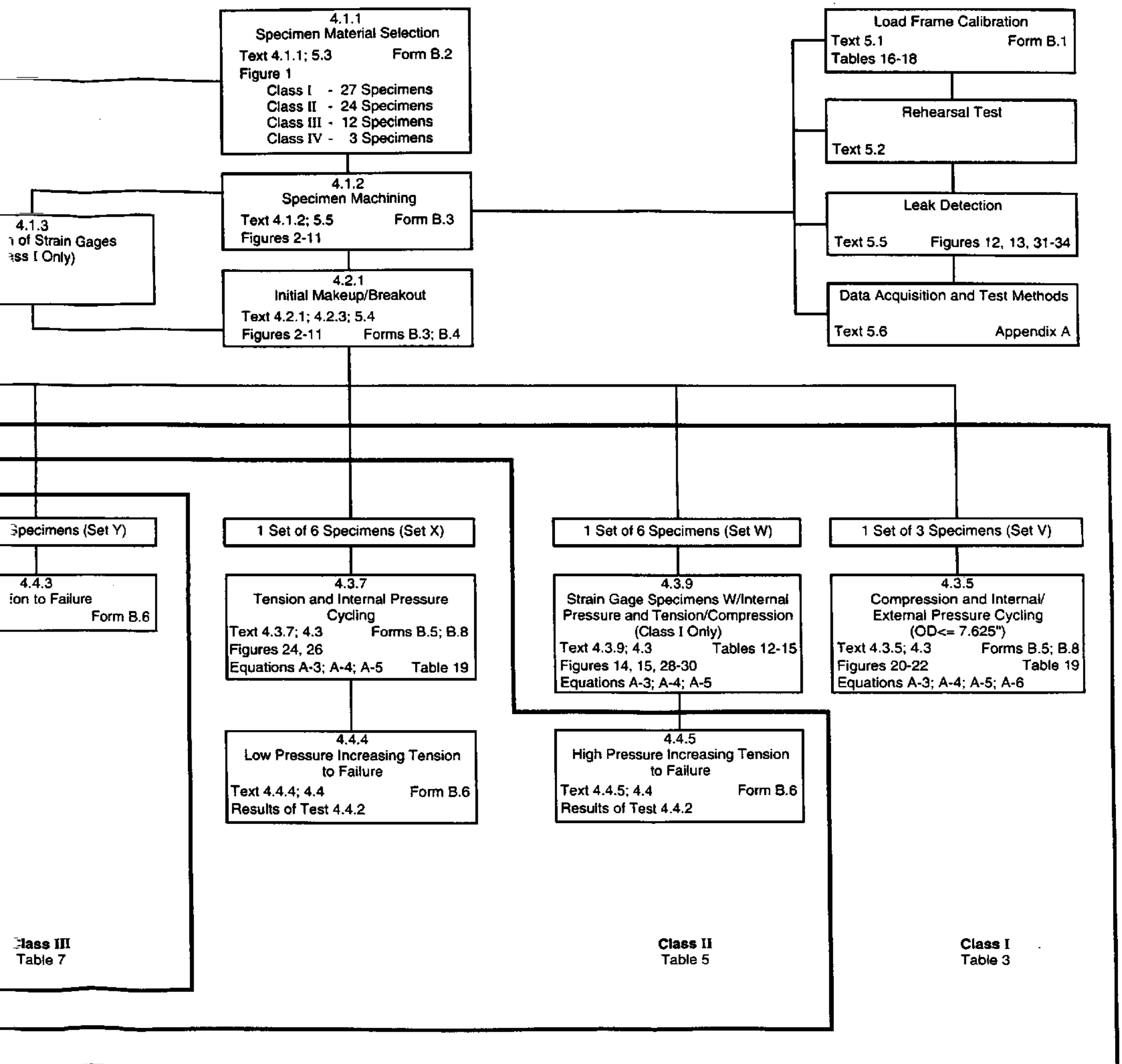


Figure F-1—Casing

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

Table 1
Example Relationship Between Test Classes and Service Application [1]

Differential Working Pressure	Connector Test Classes: Production Tubulars Service Severity High	Production Tubulars Normal	Production Tubulars Low	Drilling Tubulars Service Severity High	Drilling Tubulars Normal	Drilling Tubulars Low
Over 12000 psi	I	I	II	I	II	III
8000-12000 psi	I	II	III	II	II	III
4000-8000 psi	II	III	III	III	III	IV
0-4000 psi	III	IV	IV	IV	IV	IV

[1] The values quoted for differential working pressure are intended for guidance only. It may be necessary to apply criteria other than differential working pressure such as risk, severity of service, and environmental considerations to select the class of tests appropriate for a paticular application.

4.1.3
Installation of Strain Gages
(Class I Only)
Text 4.1.3
Figures 14, 15

Class IV
Table 10

1 Set of 3 Specimens (Set Z)

4.3.1
Initial Capped-End Pressure Cycling
Text 4.3.1; 4.3 Forms B.5; B.8
Figure 16 Equation A-1

4.2.2
Final Makeup/Breakout
Text 4.2.2; 5.4 Forms B.3; B.4
Figures 2-11

4.3.2
Final Capped-End Pressure Cycling
Text 4.3.2; 4.3 Forms B.5; B.8
Figure 17 Equations A-1; A-4

Class III
Table 8

1 Set of 6 Specimens (Set Z)

4.3.3
Initial Capped-End Pressure Cycling W/Thermal Cycling
Text 4.3.3; 4.3 Forms B.5; B.8
Figure 18 Equations A-1; A-2

4.2.2
Final Makeup/Breakout
Text 4.2.2; 5.4 Forms B.3; B.4
Figures 2-11

4.3.4
Final Capped-End Pressure Cycling W/Thermal Cycling
Text 4.3.4; 4.3 Forms B.5; B.8
Figure 19 Equations A-1; A-2; A-4

4.4.2
Capped-End Pressure to Failure
Text 4.4.2; 4.4 Form B.6

1 Set of 6 Specimens (Set Y)

4.4.3
Tension to Failure
Text 4.4.3; 4.4 Form B.6

Figure F-2—Tubing

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

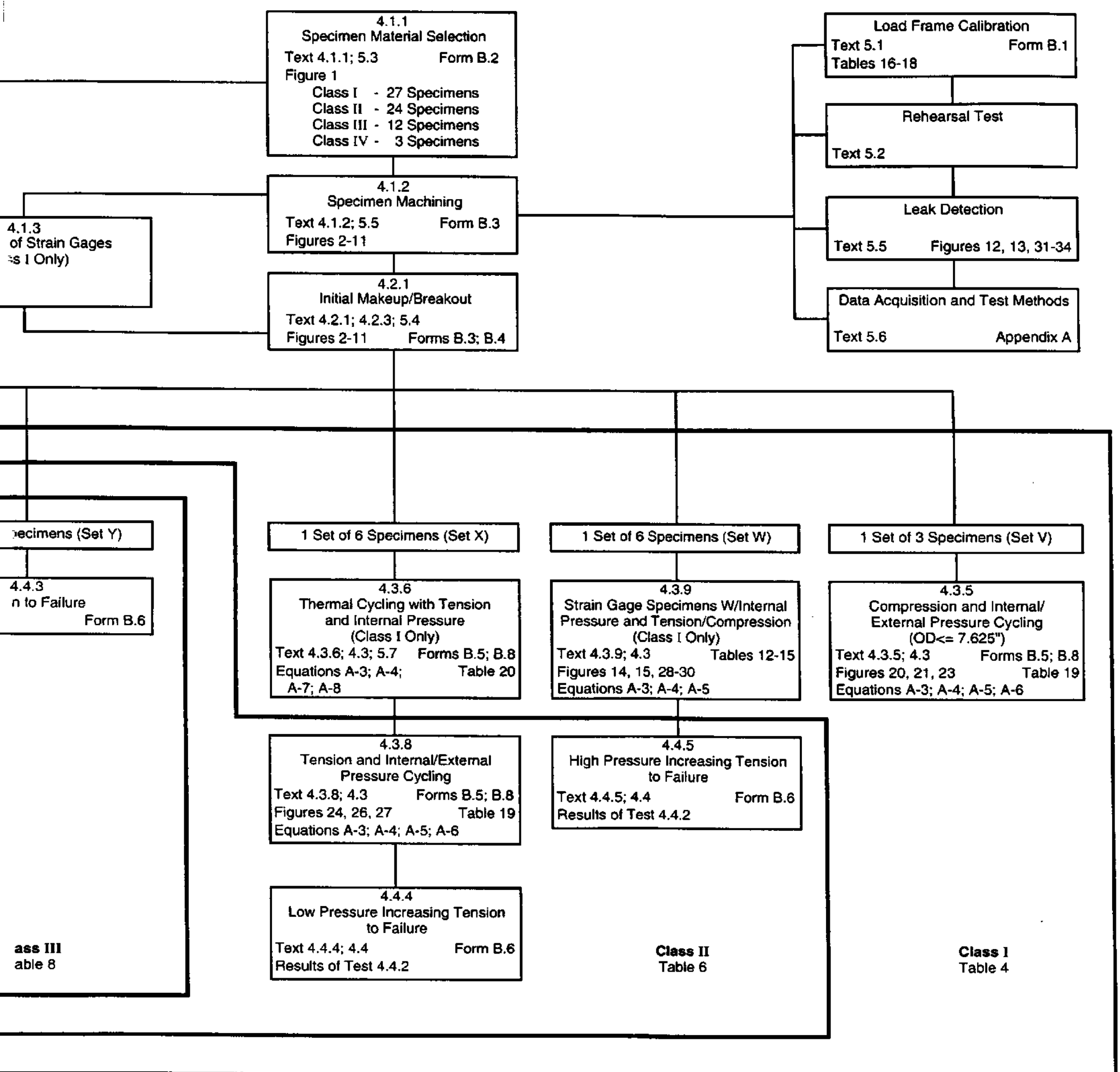


Figure F-2—Tubing

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

PC-01200—11/96—2M (4E)

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000

Additional copies available from API Publications and Distribution:
(202) 682-8375

Information about API Publications, Programs and Services is available on the World Wide Web at: http://www.api.org

American Petroleum Institute
1220 L Street, Northwest
Washington, D.C. 20005-4070
202-682-8000

Order No. G05C52

COPYRIGHT 2000 American Petroleum Institute
Information Handling Services, 2000