

COLLAPSE TESTS OF PIPE CASING AND TUBING

SOUTHWEST RESEARCH INSTITUTE TEST PROCEDURES

SwRI 18-5C3-TP-1

TEST CONTRACTOR

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S O U T H W E S T R E S E A R C H I N S T I T U T E

TEST PROCEDURES

1.0 Summary

The Services of Contractor, Southwest Research Institute (SwRI,) necessary to perform and complete collapse tests of steel pipe casing, API casing, and/or steel tubing will be furnished in accordance with terms and conditions set forth in the “Client’s” Purchase Order, Work Order, or other contract mechanism found mutually acceptable to SwRI and Client. All collapse tests are performed in accordance with American Petroleum Institute (API) Bulletin 5C3, Paragraph 2.3. Data reporting on test results may not include process of manufacture, type of heat treatment, type of straightening, and pipe sample physical properties, as this information is not made available to SwRI by manufacturers. Physical properties tests can be provided by SwRI, as well as other services such as residual stress measurements and collapse pressure tests under axial tension and compression loading.

2.0 Objective

The objective of subjecting tubular samples to an external pressure test under API 5C3 guidelines is to determine the maximum collapse resistance of a tubular specimen. Test specimen collapse pressure is defined as the maximum external pressure required to collapse the specimen. If a specimen does not collapse at the maximum rated pressure capability of the test chamber, the maximum pressure attained is reported along with the statement that it did not collapse. In some cases, dimensional measurements may have to be repeated after a test to note any changes in the physical characteristics of the test specimen from pre-test measurements.

3.0 References

American Petroleum Institute (API) Bulletin 5C3 Sixth Edition, October 1, 1994.

4.0 API Test Requirements

All collapse tests performed at SwRI will be conducted in compliance with API Bulletin 5C3, Paragraph 2.3, with the exceptions in data reporting as noted in Summary of this procedure. The following are the requirements of API 5C3, Paragraph 2.3 for collapse tests performed at SwRI.

4.1 Test Specimen

The test specimen shall have a length at least twice the outside diameter.

4.2 Test Apparatus

The test apparatus shall be such as to expose the full specimen length to the test pressure. It shall not impose radial or axial restraint or axial load on the specimen, either mechanically or hydraulically, and shall not apply pressure to the inside surface of the specimen. To ensure that the specimen is not axially restrained during testing, the initial clearance between the end of the

specimen and the end of the test chamber must be at least 0.06 inch for a test specimen 28 inches or less in length and proportionately greater for a longer test specimen.

The test chamber shall be equipped with a maximum reading pressure measuring device that is open to the test chamber during the test. The device shall have a minimum of 750 divisions between zero and its maximum working pressure and shall be certified by the manufacturer to be accurate within one-fourth of 1 percent of the full scale reading.

The pressure measuring device shall be equipped with a dampening system to bleed pressure slowly from the device at the time of specimen collapse.

The pressure measuring device shall be calibrated at intervals of six months by means of a dead weight tester or more frequently if there is reason to doubt its accuracy. The percentage of error within the working range of the pressure measuring device shall not exceed 1.0 percent.

Note: The 1.0 percent level of accuracy corresponds to the accuracy required of tension-testing machines (ASTM E4.)

4.3 Test Procedure

The exterior surface of the specimen shall be hydraulically loaded at a sufficiently slow rate to permit reading of the collapsing pressure within the specified accuracy.

4.4 Data Reporting

The following data shall be reported:

- a.) The API designation of the test specimen pipe, such as nominal diameter, nominal weight per foot, and grade.
- b.) The average outside diameter and the difference between maximum and minimum outside diameters of the specimen (ovality.) A pi-tape may be used to obtain the average outside diameter. The difference between the maximum and minimum outside diameters (ovality) may be obtained by using an ovality gauge as shown in Figure 1.
- c.) The average wall thickness and the difference between maximum and minimum wall thickness based on eight readings of the specimen.
- d.) Process of manufacture:
 - 1.) Seamless S
 - 2.) Welded W
- e.) Type of heat treatment:
 - 1.) Normalized NR
 - 2.) Normalized and tempered NT
 - 3.) Quenched and tempered QT
 - 4.) None AR

- f.) Type of straightening:
 - 1.) Rotary R
 - 2.) Hot Rotary H
 - 3.) Press P
 - 4.) None N

- g.) The clearance between the end of the test specimen and the test chamber.

- h.) The test specimen length.

- i.) The physical properties representing the collapse test specimen, including yield strength, tensile strength, and percent elongation in accordance with API Specifications 5CT [*ISO 11960, in process*] and 5D, from a tensile test specimen taken from the same length of pipe as the collapse test specimen and adjacent to it.

- j.) The test specimen collapse pressure, defined as the maximum external pressure required to collapse the specimen. If the specimen did not collapse, the maximum pressure attained shall be reported along with the statement that it did not collapse.

5.0 Safety Procedures

Reference: 29 CFR 1910.1450, the current SwRI Safety Policy and Procedures Manual. The SwRI Bldg. 81 (High Pressure Laboratory) Standard Operating Procedures.

6.0 Applicability

Procedures specified in this document and in the above referenced documents are applicable to all staff* working in the Building 81 laboratory or remote test sites where the Test and Evaluation Section of Division 18 conduct tests. These documents should be adhered to when work involves the use of any high-pressure equipment.

*Includes part-time workers, visitors, witnesses.

7.0 Quality Assurance

Southwest Research Institute has developed quality programs to meet ISO 9000 Series, ISO Guide 25, NQA-1, API Q1, and many others in support of the diverse research and development activities conducted at the Institute. Our Quality Program is fully documented in a Quality System Manual (QSM) and in operating procedures that have been audited and approved by outside agencies to verify the effectiveness of their implementation.

Calibration of pressure equipment shall be performed in accordance with SwRI UEL-DOP-65, Revision 1 (Pressure Calibration of Pressure Indicating Devices.)

8.0 Confidentiality

No test reports, data, progress, or any other information related to these tests shall be disclosed to any person not associated with Client's company. Any release of information other than to Client shall be cleared through Client, in writing, prior to release of such information.

No person from another company will be allowed to witness any of the tests at SwRI unless approval from Client, in writing, is received. Third party inspection should be verified with Client prior to tests.

9.0 Collapse Test Procedures

9.1 Sample Receipt

Upon receipt of pipe sample/samples at SwRI, obtain shipping documents from driver and ascertain that all samples shipped are accounted for. This should be done by verifying number of samples received versus number shipped and/or by verifying sample numbers on documents versus samples on hand.

If there are any anomalies in shipment, notify driver, SwRI Receiving Department, and client.

Samples are shipped in various lengths to SwRI. Check with Client's Purchase Order, SwRI Project Manager, or Lab Supervisor to determine the sample size that will be required for the tests. Sample size may vary from an L/D (length of diameter ratio) of two times to eight times and in some instances, special lengths to fit the appropriate test chamber may have to be cut.

Determine whether sample is prepared for tests or if cutting or machining will be required to cut sample to size and prepare ends. The outside diameter of the pipe will determine whether the pipe sample can be saw cut or will require machining. Normally, pipe diameters 11.00 inches and smaller may be cut by saws at SwRI. Larger diameter samples will have to be machined.

If sample is received in a not ready for test condition, (ends not cut within tolerance/not cut to proper length) the sample will be saw cut or machined to proper length with true ends. Sample length must be a minimum of two (2) times the O.D. for any sample to be acceptable for API use. The sample length may have a tolerance of $\pm .250$ inches. The ends should be cut true to within $.062$ inches. Some sawcut samples may have ends cut at an angle too great to be tested since sealing the ends becomes a problem. Verify with lab supervisor if the end must be re-cut to effect a seal on the sample.

10.0 Dimensional Measurements

After the pipe sample is cut to its' proper test length, dimensional measurements shall be performed on each sample in accordance with API Paragraph 2.3.4. Record all available information such as the manufacturer/supplier, sample number, pipe lot number, material type and heat, nominal outside diameter, weight per foot, grade, and length on the SwRI Pipe Collapse Data Sheet shown in Figure 2.

Measure wall thicknesses at eight equal spaces on one end of the pipe sample. Record on SwRI Pipe Collapse Data Sheet. Average outside diameter of sample will be measured using a pi-tape sized for nominal pipe diameter. Record average outside diameter in Data Sheet.

Measure ovality of the pipe sample using a calibrated Ovality Gauge. Measurement should be performed at the center of the sample, assuring that the surface is smooth and free of paint, rust, or scale. Obtain a reading for the difference between the maximum and minimum outside diameters of the sample and record in Data Sheet.

If additional dimensions are requested by client, record on a separate Data Sheet containing all pertinent information of the sample and dimensions recorded.

11.0 Collapse Test

Prior to starting collapse testing, verify that the calibration is up to date on all instrumentation that will be used on the test. Verify the instruments' calibrations are within required tolerances in accordance with **SwRI Calibration Procedure UEL-DOP-65, Revision 1**.

If any of the pressure readout equipment is not within required tolerances, perform calibration on pressure transducer and readout using dead weight tester and procedure referenced above. Place new calibration stickers on units showing date of calibration and date due.

Review SwRI Pipe Collapse Data Sheet to assure that all required information required of sample has been recorded on data sheet. Any missing information should be reported to lab supervisor.

Sample will be fitted onto special SwRI test collapse fixtures according to length and O.D. The test fixture consists of two seal end plates with diameter closely matching the O.D. of the sample and a solid steel mandrel that is sized to fit inside the sample with the length of the mandrel approximately matching the pipe sample length. The mandrel is connected to the seal plates by means of threaded fasteners. Figure 3 shows arrangement of the test sample and fixture in pressure vessel.

Affix the mandrel to the bottom seal plate. Mount the test sample onto the test fixture. The sample should be fitted over the mandrel onto the bottom seal plate. Seal the pipe sample to the bottom seal plate using the SwRI developed soft seal technique.

Fill the pipe sample with fresh water and thread the top plate onto the mandrel. A minimum gap of .125" should remain between the test sample and the top plate to assure that the sample is not axially restrained during the test.

Seal the pipe sample to the top seal plate using the same sealing technique as used on the bottom plate. Connect a high-pressure hydraulic line to the threaded NPT port on the top seal plate of fixture and connect to test chamber penetration. The line will be used for venting the water inside of the pipe sample to atmosphere while testing. This will prevent any differential pressure buildup.

Place test sample in appropriate test chamber for test, using required or estimated collapse pressure and size of sample to determine test chamber to be used. Fill test chamber with fresh water at ambient temperature and seal chamber when filled.

Zero instrumentation, and set peak hold function on digital readout. This will enable instrumentation to capture the maximum attained pressure in the test chamber during the test and establish collapse pressure of the sample.

Increase pressure uniformly inside the pressure vessel until the sample collapses or maximum rated test chamber pressure is attained, whichever comes first.

Pipe sample collapse is identified by means of sudden pressure drop in test chamber, audible sound, venting of the test chamber, and visual inspection after removal from test chamber. Make certain that sample has collapsed. It is possible to have a seal failure without sample collapsing.

Remove test sample from fixture after collapse has been verified, record collapse pressure in Pipe Collapse Data Sheet, date of test, and any remarks on the test or sample.

12.0 Final Report

Southwest Research Institute will issue a final report, usually in letter form, documenting test procedures and test results, sample information, and number of samples tested. A table as shown in Figure 4 will also be included in spreadsheet format. The table includes sample number, wall thicknesses, average wall thickness, percent variance, average O.D., ovality measurements, outside diameter/thickness ratio, nominal diameter, nominal weight, length, collapse pressure, and grade.

SOUTHWEST RESEARCH INSTITUTE

PIPE COLLAPSE DATA SHEET
 (Ref. API Bulletin 5C3, Paragraph 2.3)

Test Conducted by: _____ Project Number: _____
 Test Data Review: _____ Test Date: _____

Pipe Specimen Number: _____
 Pipe Lot Number: _____
 Material Type and Heat: _____
 Manufacturer: _____
 Nominal Diameter (in.) _____ Weight (lb/ft) _____
 Length of Test Specimen (in.) _____

Thickness Measurements:	
Position	Thickness (in.)
1	_____
2	_____
3	_____
4	_____
5	_____
6	_____
7	_____
8	_____
Diameter of Pipe (measured in) _____	
<u>Ovality of Pipe (in.)</u>	
Maximum	_____
Minimum	_____
Collapse Pressure _____ (psig)	

General Observations or Comments:
P.O. Number
TEST WITNESSES:

C:\WP\W18\W18\DOC\BPCDG.JR\q1

Figure 2. Pipe Collapse Data Sheet

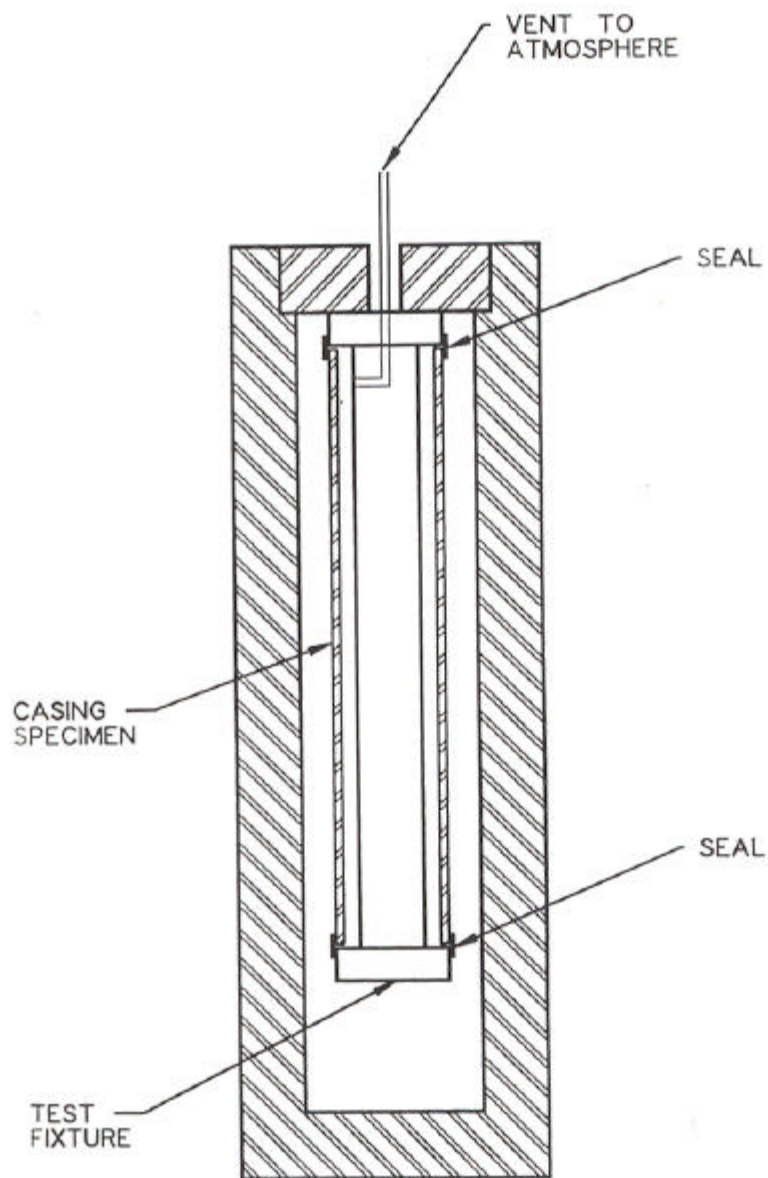


Figure 3. Collapse Test Setup

TABLE I

SPECI- MEN NUMBER	WALL THICKNESS (IN.)										QUALITY (IN.)				PIPE SAMPLE SPECIFICS						
	A	B	C	D	E	F	G	H	AVG.	VARIANCE (%)	Do* (IN.)	MAX.	MIN.	MAX.-MIN.	VARIANCE (%)	Do/Do**	NOMINAL DIA. (IN.)	NOMINAL WGT. (LB/FT)	LENGTH (IN.)	MEASURED COLLAPSE PRESSURE (PSIG)	GRADE
x	0.312	0.315	0.308	0.310	0.324	0.322	0.317	0.306	0.319	0.085	0.944	0.998	-0.004	0.01	0.189	17.621	5.593	17.89	11.00	12.671	P110
x	0.285	0.301	0.312	0.322	0.326	0.319	0.328	0.308	0.314	0.894	0.943	0.999	-0.009	0.014	0.253	17.674	5.599	17.89	11.00	13.197	P110
x	0.327	0.326	0.329	0.316	0.311	0.311	0.319	0.321	0.320	5.825	5.590	0.914	-0.001	0.015	0.279	17.344	5.599	17.89	11.00	14.269	P110
x	0.313	0.314	0.316	0.324	0.328	0.331	0.317	0.306	0.319	7.866	5.543	0.910	-0.004	0.014	0.253	17.367	5.590	17.99	11.00	13.271	P110
x	0.329	0.336	0.310	0.321	0.311	0.312	0.327	0.314	0.319	6.267	5.536	0.908	-0.004	0.012	0.217	17.354	5.599	17.89	11.00	14.290	P110
x	0.322	0.334	0.342	0.331	0.319	0.305	0.309	0.322	0.322	12.719	5.545	0.908	-0.002	0.01	0.189	17.296	5.590	17.99	11.00	13.237	P110
x	0.334	0.338	0.313	0.314	0.326	0.331	0.334	0.337	0.328	7.326	5.543	0.909	-0.003	0.011	0.189	18.019	5.590	17.99	11.00	13.800	P110
x	0.305	0.315	0.322	0.328	0.330	0.339	0.338	0.311	0.322	10.288	5.544	0.913	0	0.013	0.234	17.291	5.590	17.99	11.00	13.864	P110
x	0.319	0.318	0.314	0.326	0.322	0.327	0.329	0.327	0.321	8.206	5.544	0.903	-0.009	0.009	0.182	17.271	5.590	17.99	11.00	12.889	P110
x	0.324	0.321	0.324	0.322	0.326	0.319	0.384	0.318	0.322	8.324	5.546	0.912	-0.001	0.012	0.234	17.237	5.590	17.99	11.00	13.286	P110
x	0.323	0.321	0.315	0.309	0.320	0.329	0.333	0.333	0.323	7.433	5.543	0.912	-0.006	0.018	0.329	17.168	5.590	17.99	11.00	13.867	P110

* Average Outside Diameter

** Average Diameter/Average Wall Thickness

Figure 4. Table 1