API Spec 10D
Casing bow-spring centralizers and centralizer subs
Introduction


Users of this standard should be aware that further or differing requirements may be needed for individual applications. This standard is not intended to inhibit a vendor from offering, or the purchaser from accepting, alternative equipment or engineering solutions for the individual application. This may be particularly applicable where there is innovative or developing technology. Where an alternative is offered, the vendor should identify any variations from this standard and provide details.

In this standard, where practical, U.S. Customary units are included in brackets after SI units for information.
API Spec 10D — Casing bow-spring centralizers and centralizer subs

1 Scope

This Standard provides minimum performance requirements, test procedures and marking requirements for casing bow-spring centralizers and centralizer subs for the petroleum and natural gas industries. The procedures provide verification testing for the manufacturer’s design, materials and process specifications, and periodic testing to confirm the consistency of product performance.

This standard is not applicable to rigid or positive centralizers.

2 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

API Spec 5CT/ISO 11960, Petroleum and natural gas industries — Steel pipes for use as casing or tubing for wells

3 Terms and definitions

For the purposes of this standard, the following terms and definitions apply.

3.1 flexed condition of a bow spring when a force three times the specified minimum restoring force (± 5 %) has been applied to it

3.2 holding device device employed to fix the stop collar or centralizer to the casing

EXAMPLES Set screws, nails, mechanical dogs and epoxy resins.

3.3 holding force maximum force required to initiate slippage of a stop collar on the casing

3.4 hole size diameter of the wellbore in which the centralizer is placed. This may be the cased hole or open hole.

3.5 restoring force force exerted by a centralizer against the casing to keep it away from the wellbore wall

NOTE Restoring force values can vary based on installation methods.
3.6
**rigid centralizer**
centralizer manufactured with bows that do not flex

3.7
**running force**
maximum force required to move a centralizer through a specified wellbore diameter

NOTE Running-force values can vary depending on the installation methods.

3.8
**standoff**
smallest distance between the outside diameter of the casing and the wellbore

3.9
**standoff ratio**
ratio of standoff to annular clearance

NOTE It is expressed as a percentage.

3.10
**starting force**
maximum force required to insert a centralizer into a specified wellbore diameter

NOTE Starting-force values can vary depending on the installation methods.

3.11
**stop collar**
device attached to the casing to prevent movement of a casing centralizer

NOTE A stop collar can be either an independent piece of equipment or integral with the centralizer.

3.12
**Annular clearance**
Radial clearance between the OD of the casing and the open hole in which the centralizer is run

3.13
**Minimum restriction**
The smallest diameter a particular centralizer or centralizer sub was designed to pass through, or the smallest diameter it will pass through in a particular application

3.14
**Open hole**
The newly drilled section of the well located below the cased hole in which the centralizer will be used

3.15
**Rotating centralizer**
Any centralizer that once installed on casing or a casing sub will allow the casing to rotate freely without damage to the centralizer, the previous casing, the well bore, or generate and appreciable wear that would change the ratings of the casing or casing sub it is installed on.

4 Requirements

4.1 Functions of a centralizer

The purpose of a casing centralizer is to facilitate running casing to the desired depth and to assist in centring the casing in the wellbore. One of the main objectives of centralizing a casing string is to facilitate a good cementing, thereby isolating fluids from different zones. A bow-spring centralizer can be constructed in various ways, using various types, shapes and quantities of bow spring.

4.2 Starting force

The maximum starting force shall be less than the weight of 12,19 m (40 ft) of casing of medium linear mass as defined in Table 1. The maximum starting force shall be determined for a centralizer in new, fully assembled condition being run in an outer pipe equal to the open hole diameter. Values for running the centralizer through restriction may be higher, and shall be acceptable at the discretion of the customer.

4.3 Restoring force

The minimum restoring force for a 67 % standoff ratio shall not be less than the values shown in Table 1. See A.2 for the derivation of the requirements.

<table>
<thead>
<tr>
<th>Casing diameter</th>
<th>Medium linear mass casing</th>
<th>Minimum restoring force at 67 % standoff ratio</th>
<th>Maximum starting force</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm (in)</td>
<td>kg/m (lb/ft) N (lbf)</td>
<td>N (lbf)</td>
<td>N (lbf)</td>
</tr>
<tr>
<td>89 (3 ½) a</td>
<td>14,7 (9,91) a</td>
<td>1 761 (396)</td>
<td>1 761 (396)</td>
</tr>
<tr>
<td>102 (4) a</td>
<td>16,9 (11,34) a</td>
<td>2 019 (454)</td>
<td>2 019 (454)</td>
</tr>
<tr>
<td>114 (4 ½)</td>
<td>17,3 (11,6)</td>
<td>2 064 (464)</td>
<td>2 064 (464)</td>
</tr>
<tr>
<td>127 (5)</td>
<td>19,3 (13,0)</td>
<td>2 313 (520)</td>
<td>2 313 (520)</td>
</tr>
<tr>
<td>140 (5 ½)</td>
<td>23,1 (15,5)</td>
<td>2 758 (620)</td>
<td>2 758 (620)</td>
</tr>
<tr>
<td>168 (6 5/8)</td>
<td>35,7 (24,0)</td>
<td>4 270 (960)</td>
<td>4 270 (960)</td>
</tr>
<tr>
<td>178 (7)</td>
<td>38,7 (26,0)</td>
<td>4 626 (1 040)</td>
<td>4 626 (1 040)</td>
</tr>
<tr>
<td>194 (7 5/8)</td>
<td>39,3 (26,4)</td>
<td>4 697 (1 056)</td>
<td>4 697 (1 056)</td>
</tr>
<tr>
<td>219 (8 5/8)</td>
<td>53,6 (36,0)</td>
<td>6 405 (1 440)</td>
<td>6 405 (1 440)</td>
</tr>
<tr>
<td>244 (9 5/8)</td>
<td>59,5 (40,0)</td>
<td>7 117 (1 600)</td>
<td>7 117 (1 600)</td>
</tr>
<tr>
<td>273 (10 3/8)</td>
<td>75,9 (51,0)</td>
<td>4 537 (1 020)</td>
<td>9 074 (2 040)</td>
</tr>
<tr>
<td>298 (11 3/8)</td>
<td>80,4 (54,0)</td>
<td>4 804 (1 080)</td>
<td>9 608 (2 160)</td>
</tr>
<tr>
<td>340 (13 3/8)</td>
<td>90,8 (61,0)</td>
<td>5 427 (1 220)</td>
<td>10 854 (2 440)</td>
</tr>
<tr>
<td>406 (16)</td>
<td>96,7 (65,0)</td>
<td>5 783 (1 300)</td>
<td>11 565 (2 600)</td>
</tr>
<tr>
<td>473 (18 5/8)</td>
<td>130,2 (87,5)</td>
<td>7 784 (1 750)</td>
<td>15 569 (3 500)</td>
</tr>
<tr>
<td>508 (20)</td>
<td>139,9 (94,0)</td>
<td>8 363 (1 880)</td>
<td>16 725 (3 760)</td>
</tr>
</tbody>
</table>
4.4 Frequency of testing

4.4.1 Tests for design and process verification shall be performed for a minimum of six conventional casing-based prototype centralizers. All of the tested centralizers shall conform to the performance requirements of Table 1. Due to the variety and custom nature of the sub-based centralizers (centralizer subs), a minimum of one centralizer sub shall be tested per centralizer casing size, configuration, and hole size. Data for multiple hole sizes can be established for the same centralizer configuration.

4.4.2 For confirmation of the consistency of product performance, testing shall be performed at least annually for each size of centralizer manufactured to this standard in quantities greater than 500 per year. Corrective action shall be implemented and documented for the centralizer size in question if the tested centralizer does not conform to the performance requirements of Table 1.

5 Testing equipment

5.1 Test stand

The test stand allows application of vertical loads and is capable of measuring these loads and vertical displacements. Examples of typical equipment are shown in Figures 1 and 2.

Key
1 Inner pipe  
2 Outer pipe  
3 Equally spaced lugs

| a Casing diameter |
| b Hole diameter |

Figure 1 — Example of casing centralizer starting-force test equipment
5.2 Instrumentation

Instrumentation of the test stand shall allow displacement readings of 1,6 mm (1/16 in) or smaller.

5.3 Accuracy

5.3.1 Accuracy of load measurements shall be within 5 % of the measured value.

5.3.2 Accuracy of displacement measurements shall be within 0,8 mm (1/32 in).

5.3.3 Calibration of all measuring equipment shall be performed at least annually.

5.4 Test pipe

5.4.1 Inner pipe (casing or centralizer sub see Figures 1 and 2)

The inner pipe shall be longer than the centralizer in the flexed condition and longer than the outer pipe. For casing-based centralizers, the outside diameter of the inner pipe shall be within the tolerances shown in ISO 11960 for non-upset pipe. Burrs or similar defects shall be removed. For a centralizer sub, the inner pipe shall be manufactured to the same dimensional requirements as the centralizer sub body that the centralizer will be used on for production.

Surfaces on the ends of the inner pipe, outside the length to be covered by the centralizer and other test components, are exempt from the above requirement.

5.4.2 Outer pipe (see Figures 1 and 2)

The outer pipe shall be longer than the centralizer bow spring in the flexed condition. The inside diameter of the outer pipe shall be equal the hole size for which the centralizer is to be used. The outside diameter shall be as shown in ISO 11960 for non-upset pipe. Burrs or similar defects shall be removed. The upper end of the outer pipe used for the starting-force test may be bevelled on the inside to a maximum of 45°, with a maximum larger-pipe inside diameter of +3,2 mm (1/8 in). For typical casing-based centralizer applications, where the open hole is smaller than the previous casing, the leading edge of the outer pipe used for the starting force test may be beveled on the inside to a maximum of 45°, with a maximum larger-pipe inside diameter +.125 in (3.2 mm). For sub based centralizers in tight-tolerance applications, where the open hole is larger than previous casing, the leading edge of the outer pipe used...
for starting force test may be beveled on the inside to a minimum of 30° (from axis of pipe) to a maximum larger-pipe inside diameter +0.125 in (3.2 mm). This is to simulate running through wellheads and down hole crossovers.

The end of the outer pipe (other than the upper end used for starting-force tests), beyond the length covered by the centralizer when flexed during the restoring-force test, is exempt from the above requirements.

6 Procedure for starting-force and running-force tests for centralizer applications where previous casing ID is greater than or equal to (>=) the open hole ID.

6.1 Starting-force test

6.1.1 The starting force represents the maximum force required to insert the inner pipe into the outer pipe (after compensating for the weight of the inner pipe and attachments). It is determined as described in 6.1.2 to 6.1.6.

6.1.2 Install a centralizer in new, fully assembled condition as shown in Figure 1 on the inner pipe over four equally spaced lugs, with each lug protruding not more than 0.64 mm (1/4 in) beyond the outer surface of the inner pipe.

NOTE Under field conditions, there are many different methods of attaching a centralizer to the casing. The starting and restoring forces for all types of holding devices may not be the same as the test results obtained using this procedure.

6.1.3 The test assembly shall be within 5° of vertical.

6.1.4 Lubricate the contacting surfaces with a petroleum-base grease before running the test.

6.1.5 With the centralizer resting on the edge of the outer pipe, apply a load to the inner pipe to pull the centralizer into the outer pipe.

6.1.6 Take readings of force used, from the time the load is first applied until the centralizer is completely inside the outer pipe. Report the maximum force as the starting force after compensation as in 6.1.1.

6.2 Running-force test

6.2.1 The running force represents the maximum force required to slide the inner pipe inside the outer pipe once the force reading has become steady (after compensating for the weight of the inner pipe and attachments).

6.2.2 The result of this test is not required to conform to a maximum value. However, the test shall be performed and the results recorded.

6.2.3 The running-force test may be performed with the starting-force test, or carried out separately.

6.2.4 Take readings of force used from the time the centralizer is inside the outer pipe until the inner pipe is completely in place. Report the maximum force as the running force after compensation as in 6.1.1.

7 Procedure for restoring-force test

7.1 Perform the test with the inner pipe and the outer pipe within 5° of horizontal, see Figure 2.
7.2 Prior to collecting the force data for the test, flex all bow springs 12 times.

7.3 Apply an external force to the outer pipe so that it will be transferred to the inner pipe vertically through the point of contact of the centralizer with the outer pipe, see Figure 2.

7.4 Apply load and record load-deflection readings at a minimum of 1.6 mm (1/16 in) increments until three times (± 5 %) the minimum restoring force has been obtained, see Table 1. The travel distance to obtain 67 % standoff shall be determined for each test position.

7.5 Repeat the process, testing the centralizer until each spring and each set of springs has been tested in positions 1 and 2 as shown in Figure 3.

![Figure 3 — Casing centralizer test positions](image)

7.6 Calculate the total load at each deflection by compensating for the mass of the travelling pipe and attachments.

7.7 Prepare the final load-deflection curve using the arithmetic average of the force readings at corresponding deflections. Restoring force shall be determined from this curve at 67 % standoff ratio.
8 Testing sequence for centralizer applications where previous casing ID is less than (<) the open hole ID.

8.1 Install a new centralizer on the test pipe

8.2 Measure OD of centralizer and record

8.3 Measure starting and running force of a newly manufactured centralizer in outer pipe equal to the open hole

8.4 Measure OD of centralizer and record

8.5 Measure restoring force of centralizer from previous test in outer pipe equal to open hole

8.6 Measure OD of centralizer and record

8.7 Install a new centralizer on the test sub. (If the over-the-bow measurement of the centralizer used in the previous test (step 8.5) shows less than a 6.35 mm (0.250 in) reduction it does not need to be replaced and can be used for this test)

8.8 Measure OD of centralizer and record if a new centralizer is used, or use values from step 8.6 if the same centralizer met the conditions of step 8.7.

8.9 Measure starting and running force of a newly manufactured centralizer (or the unaltered previously tested centralizer) in the outer pipe equal to the minimum restriction.

8.10 Measure OD of centralizer and record.
8.11 Measure starting and running force of centralizer from previous test (step 8.9) in outer pipe equal to open hole size.
8.12 Measure OD of centralizer and record.
8.13 Measure restoring force of centralizer from previous test (step 8.11) in outer pipe equal to open hole size.
8.14 Measure OD of centralizer and record.

9.0 Procedures for starting-force and running-force test where previous casing ID is less than (<) the open hole ID.

Starting-force test

9.1 The starting force represents the maximum force required to insert the inner pipe into the outer pipe (after compensating for the weight of the inner pipe and attachments).
9.2 Ensure the centralizer is properly secured to the inner pipe.
9.3 Set both the test assembly and outer pipe within 5° of vertical for testing.
9.4 Lubricate the contacting surfaces with petroleum-based grease before running the test.
9.5 With the centralizer resting on the edge of the outer pipe apply a load between the two pipes such that the centralizer is pushed into the outer pipe.
9.6 Take readings of force used, from the time the load is first applied until the centralizer is completely inside the outer pipe. Report the maximum force as the starting force after compensation as in 9.1.

Running-force Test

9.7 The running force represents the maximum force required to slide the inner pipe inside the outer pipe once the force reading has become steady (after compensating for the weight of the inner pipe and attachments).
9.8 The result of the test is not required to conform to a maximum value. However the test shall be
performed and the results recorded.

9.9 The running–force test may be performed with the starting-force test, or carried out separately.
9.10 Take readings of force used from the time the centralizer is inside the outer pipe until the inner pipe
is completely in place. Report the maximum force as the running force after compensation as in
9.1.

10.0 Procedure for restoring-force test where previous casing ID is less than (<) the
open hole ID.

10.1 Perform the test with the inner pipe and the outer pipe within 5° of horizontal.
10.2 Prior to collecting the force data for the test, flex all bow springs 12 times (see definition of “flexed”).
10.3 Apply an external force to the outer pipe so that it will be transferred to the inner pipe vertically
through the point of contact with the centralizer with the outer pipe.
10.4 Apply load and record load-deflection readings at a minimum of .062in (1.6mm) increments until
three times (+5%) the minimum restoring force has been obtained. The travel distance to obtain
67% standoff shall be determined for each test position.
10.5 Repeat the process testing the centralizer until each spring and each set of springs has been tested
in positions 1 and positions 2 as shown in Figure 4.
10.6 Calculate the total load at each deflection by compensating for the mass of the traveling pipe and
attachments.

Prepare the final Load-Deflection curve using the arithmetic averages of the force readings at
corresponding deflections. Restoring force shall be determined from this curve at 67% standoff.

![Figure 4: Casing centralizer test positions](image)

11.0 Procedure for rotating torque test where previous casing ID is less than (<) the
open hole ID.

11.1 Perform the test with the inner pipe and the outer pipe within 5° of horizontal and inner pipe resting
on low friction, load-rated roller supports, such that the test apparatus induces minimal
contribution to torque measurement.
11.2 Measure the rotating torque of the inner pipe on the test stand with no side load conditions and
record to be used in compensating for final torque rating. This torque can be negated if less than
(<) 5-10?? Ft-lb. (for group discussion)
11.3 Apply an external force to the outer pipe, equivalent to the full API restoring force, so that it will be
transferred to the inner pipe vertically through the point of contact with the centralizer and the
outer pipe.
11.4 Record the maximum torque required to rotate the inner pipe on the roller supports, ensuring that
the outer pipe and centralizer remain stationary relative to the applied side load apparatus.

Deduct any significant values from Step 11.2 for reporting purposes.
11.5 If centralizer will be used in application where casing ID is greater than or equal to (\( \geq \)) the open hole ID, conduct and record torque measurement for the casing ID and open hole ID outer pipe conditions.

11.6 If centralizer will be used in application where casing ID is less than (\(<\)) the open hole ID, repeat and report torque measurement for both the maximum restriction and open hole outer pipe conditions.

**Figure 5:** Example of torque testing equipment

### 12.0 RECOMMENDED PROCEDURE FOR QUALIFYING A DESIGN AS ROTATING TYPE

12.1 Document the casing sub body or casing OD dimensions that will have potential contact with the centralizer components (end bands or bows) after installation. Taking OD measurements every 45 degrees to span the circumference of the body or casing at four (4) permanently marked places as a minimum (@ 0°-180°, 45°-225°, 90°-270°, 135°-315°) to be re-measured after the test.

12.2 Install centralizer per approved installation procedure.

12.3 Chuck up sub body or casing into a suitable lathe or equivalent rotating test device with the open hole outer pipe installed over the centralizer (see Fig 6.)

12.4 Apply an external force to the outer pipe, equivalent to the full API restoring force, so that it will be transferred to the inner pipe vertically through the point of contact with the centralizer and the outer pipe.

12.5 Set up a means to cool and lubricate test piece rotating contact points with fresh water.

12.6 Monitor torque transferred to the outer pipe through the centralizer while rotating the inner pipe at 20 RPM for 8 hours total. Record torque at the start of the test and every half hour until complete.

**NOTE:** Precautions should be taken to have automated emergency stop capabilities to kill rotation in the event of component lock-up or high torque spikes to prevent injury or damage to operators and equipment.

12.7 After test, remove the centralizer from the casing or sub body and compare OD body measurements from before to after (taken at point of maximum wear coincident with the angular locations of the before measurements) to determine wear and subsequent ratings impact.
13.0 PUBLISHED DATA

13.1 Starting force of new centralizer in open hole.
13.2 Running force of new centralizer in open hole.
13.3 Restoring force of new centralizer in open hole.
13.4 Starting force of new centralizer in minimum restriction.
13.5 Running force of new centralizer in minimum restriction.
13.6 Starting force of centralizer in open hole after running through minimum restriction.
13.7 Running force of centralizer in open hole after running through minimum restriction.
13.8 Restoring force of centralizer in open hole after running through minimum restriction.
13.9 Rotating torque in casing and open hole at API restoring force side load.
13.10 Rotating torque in minimum restriction and open hole at API restoring force side load.

For centralizers application where previous casing ID is greater than or equal to (>=) the open hole ID, only data for steps 13.1 through 13.3 are required to be published. For centralizers application where previous casing ID is greater than or equal to (>=) the open hole ID, and the design is to be classified as a rotating type, then data for steps 13.1 through 13.3 and 13.9 are required to be published.

For centralizer applications where previous casing ID is less than (<) the open hole ID data from all steps 13.1 through 13.9 (excluding 13.9) shall be reported. If centralizer is not classified as a rotating type then 13.10 may be excluded.
### 14.0 Specifications*

#### 14.1 Table 2:

<table>
<thead>
<tr>
<th>Size (in)</th>
<th>Medium Linear Mass (lb/ft)</th>
<th>Restoring Force (lbf)</th>
<th>Starting Force (lbf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.500</td>
<td>9.91</td>
<td>396</td>
<td>396</td>
</tr>
<tr>
<td>4.000</td>
<td>11.34</td>
<td>454</td>
<td>454</td>
</tr>
<tr>
<td>4.500</td>
<td>11.60</td>
<td>464</td>
<td>464</td>
</tr>
<tr>
<td>5.000</td>
<td>13.00</td>
<td>520</td>
<td>520</td>
</tr>
<tr>
<td>5.500</td>
<td>15.50</td>
<td>620</td>
<td>620</td>
</tr>
<tr>
<td>6.625</td>
<td>24.00</td>
<td>960</td>
<td>960</td>
</tr>
<tr>
<td>7.000</td>
<td>26.00</td>
<td>1040</td>
<td>1040</td>
</tr>
<tr>
<td>7.625</td>
<td>26.40</td>
<td>1056</td>
<td>1056</td>
</tr>
<tr>
<td>7.750</td>
<td>46.10</td>
<td>1844</td>
<td>1844</td>
</tr>
<tr>
<td>8.625</td>
<td>36.00</td>
<td>1440</td>
<td>1440</td>
</tr>
<tr>
<td>9.625</td>
<td>40.00</td>
<td>1600</td>
<td>1600</td>
</tr>
<tr>
<td>9.875</td>
<td>65.30</td>
<td>2612</td>
<td>2612</td>
</tr>
<tr>
<td>10.000</td>
<td>73.90</td>
<td>2956</td>
<td>2956</td>
</tr>
<tr>
<td>10.125</td>
<td>79.75</td>
<td>3190</td>
<td>3190</td>
</tr>
<tr>
<td>10.750</td>
<td>51.00</td>
<td>1020</td>
<td>2040</td>
</tr>
<tr>
<td>11.750</td>
<td>54.00</td>
<td>1080</td>
<td>2160</td>
</tr>
<tr>
<td>11.875</td>
<td>71.80</td>
<td>1436</td>
<td>2872</td>
</tr>
<tr>
<td>13.375</td>
<td>61.00</td>
<td>1220</td>
<td>2440</td>
</tr>
<tr>
<td>13.625</td>
<td>88.20</td>
<td>1764</td>
<td>3528</td>
</tr>
<tr>
<td>14.000</td>
<td>115.53</td>
<td>2311</td>
<td>4621</td>
</tr>
<tr>
<td>16.000</td>
<td>65.00</td>
<td>1300</td>
<td>2600</td>
</tr>
<tr>
<td>17.875</td>
<td>93.50</td>
<td>1870</td>
<td>3740</td>
</tr>
<tr>
<td>18.000</td>
<td>117.00</td>
<td>2340</td>
<td>4680</td>
</tr>
<tr>
<td>18.625</td>
<td>87.50</td>
<td>1750</td>
<td>3500</td>
</tr>
<tr>
<td>20.000</td>
<td>94.00</td>
<td>1880</td>
<td>3760</td>
</tr>
</tbody>
</table>

*NOTE: Highlighted cells are not specified in API 10D Specification; the Medium Linear Mass values were chosen based on the mass of the heaviest casing utilization at the date this specification was written.

*for sizes/weights not shown in the table above, use appendix A2 calculations for determining standoff requirement.

### 15 Marking

#### 15.1 Casing centralizers performing in conformance with this standard shall be marked by the manufacturer as specified in 8.2.
Additional markings as desired by the manufacturer or as required by the purchaser are not prohibited. The marking shall be die-stamped, paint-stencilled, or adhesive-labelled on the collars or the bow springs.

158.2 The casing centralizers shall be marked with the casing diameter on which to run the centralizers, followed by the hole diameter for which the centralizers were tested to this standard. The marking shall contain the designation API Spec 10D.

For centralizers shipped pre-assembled, diameter marking may be applied to one bow or collar only. For centralizers shipped disassembled or separate shipments of bows and collars, conformance with this standard shall be indicated on shipping documents; in this case, shipping documents shall indicate physical identification of respective components.

EXAMPLE A 140 mm (5 ½ in) centralizer meeting the requirements of this standard in a hole of diameter 200 mm (7 7/8 in) shall be marked as follows:

140 mm × 200 mm API 10D

(or 5 ½ in × 7 7/8 in API 10D if USC units are used)
Annex A
(informative)

Miscellaneous information

A.1 Load-deflection information

A typical load-deflection curve is shown in Figure A.1. The curve is prepared using the methods described in clause 7. The purpose of the curve is to provide operators with specific information on the performance of a centralizer in a given hole diameter. This information is useful for determining centralizer spacing in deviated wells.

Load vs. deflection curves may be considered to be proprietary information by the centralizer manufacturer. For this reason, publication of the curves is optional and is not required for compliance with this standard.

Starting force = 2 891 N (650 lbf)
Running force = 1 446 N (325 lbf)
a 67 % stand-off

Figure A.1 — Load vs. deflection curve for a 178 mm (7 in) centralizer in 251 mm (9 7/8 in) hole

A.2 Determination of restoring-force requirements

Field observations indicate hole deviation from vertical on an average varies from zero to approximately 60°. Therefore, an average deviation of 30° is used to calculate restoring-force requirements.

For casing diameters 273 mm (10 ¾ in) through 508 mm (20 in), where casing strings are generally placed in relatively vertical hole sections, the minimum restoring force shall be not less than:

\[ F_R = W \sin 30 = 0,5 W \]  

(A.1)

where

- \( F_R \) is the minimum restoring force, expressed in newtons;
- \( W \) is the weight of 12,19 m (40 ft) of medium linear-mass casing, expressed in newtons.

For casing diameters 114 mm (4 1/2 in) through 244 mm (9 5/8 in), where casing strings are generally placed in the deviated hole sections, the minimum restoring force shall be not less than:

\[ F_R = 2 W \sin 30 = W \]  

(A.2)

A.3 67 % standoff ratio for field applications

The 67 % standoff ratio may or may not give adequate centralization of casing in field applications. The 67 % standoff ratio is used merely for the purpose of specifying minimum performance requirements that centralizers shall meet.
Bibliography
