BS ISO 7257:2016

BSI Standards Publication

Aircraft — Hydraulic tubing joints and fittings — Rotary flexure test

National foreword

This British Standard is the UK implementation of ISO 7257:2016. It supersedes BS M 55:1984 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ACE/69, Aerospace hydraulic systems, fluids and components.

A list of organizations represented on this committee can be obtained on request to its secretary.

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ISO 7257

Second edition
2016-06-01

Aircraft — Hydraulic tubing joints and fittings — Rotary flexure test

Aéronautique — Joints et raccords pour tubes hydrauliques — Essai de flexion rotative

Reference number
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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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The committee responsible for this document is ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 10, *Aerospace fluid systems and components*.

This second edition cancels and replaces the first edition (ISO 7257:1983), which has been technically revised to add imperial unit equivalents, three DN sizes, and for additional clarifications.

Introduction

This International Standard describes a flexure fatigue test procedure which allows evaluation of various tube fitting designs or material combinations. This evaluation is performed by fatigue testing the tube joints over a spectrum of bending stresses and then plotting the cycles to failure. Other test methods may be used as long as they develop the same data as the rotary flexure test.

Aircraft — Hydraulic tubing joints and fittings — Rotary flexure test

1 Scope

This International Standard specifies a flexure test procedure to determine and classify the fatigue strengths of reconnectable or permanent hydraulic tube joints.

The procedure is intended for conducting flexure tests of fittings and joints with high-strength hydraulic tubes of various alloys such as corrosion resistant steel, Nimonic™[1)], titanium and aluminium alloy hydraulic tube for use on commercial and military aircraft.

A mean stress is applied by holding system pressure in the specimens and then flexing in a rotary bending test machine.

2 Requirements

2.1 Flexure test device

The test device should be capable of testing in-line or bulkhead union test specimens and other configurations such as elbows and tees.

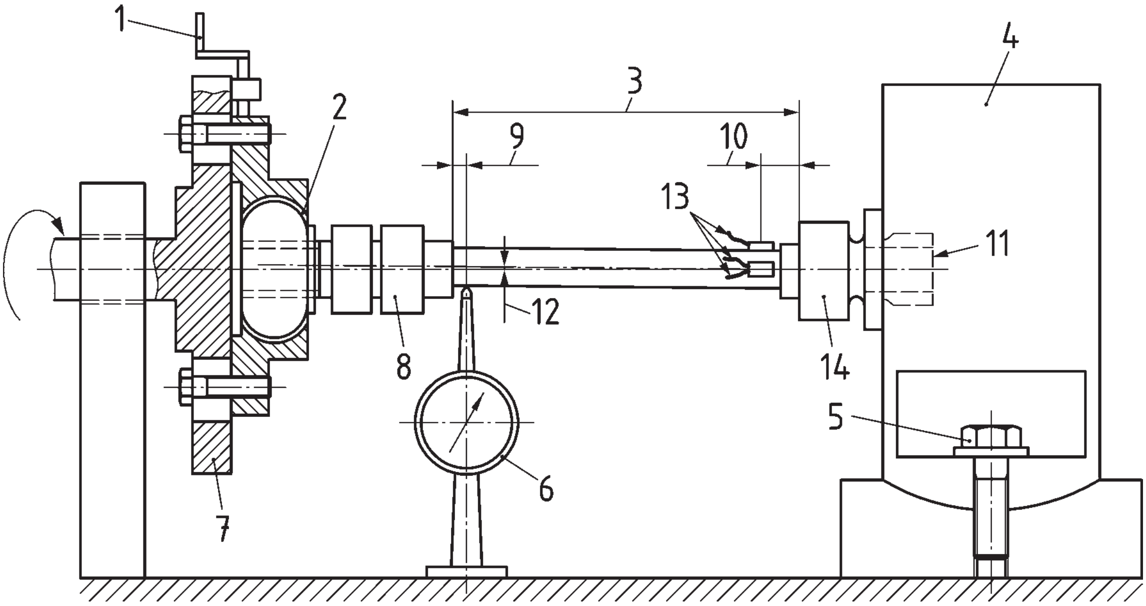
The rotary flexure test device should be similar to that shown in Figure 1. Each rotary flexure test device should be capable of testing one specimen, but several specimens may be mounted on one plate.

The device should be capable of constantly maintaining the required operating pressure during the test. The test fluid shall be water or system fluid (working fluid) unless otherwise specified by the responsible authorities. A typical pressurization and automatic shutdown system is shown in Figure 2. The shut-down should be automatic in the event of failure or pressure drop. The device should be capable of testing at controlled constant temperature, if specified by the procuring agency. The tailstock of the test device should be designed to permit alignment during initial installation and specimen mounting, and to serve as a pressure manifold. The rotating headstock should have a low-friction, self-aligning bearing and should be designed to permit total deflections of up to 25 mm/1 inch, and a constant rotational frequency within the range of 1 500 min^{-1} to 3 600 min^{-1}. The base should be of rigid construction.

2.2 Flexure test specimen

The test specimen should be consisting of an adapter fitting (headstock end), a section of straight tubing, and a test fitting at the tailstock end. Typical test specimens are shown in Figure 3. The tubing shall be of a size and wall thickness as specified by the user or procuring agency.

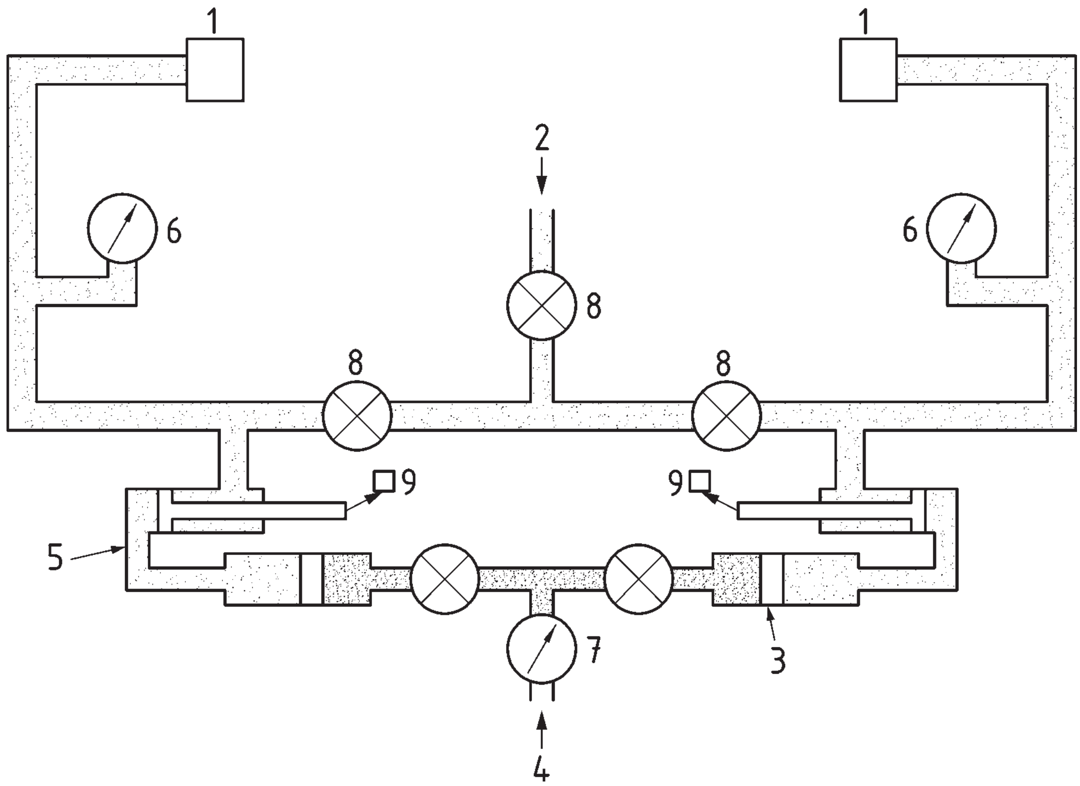
1) Nimonic™ is the trademark of a product supplied by Special Metals Corporation. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products can be used if they can be shown to lead to the same results.



Key

1	adjustment for deflection	8	adapter fitting
2	self-aligning bearing (without torsion on test joint)	9	10 mm/0,400 inch max
3	test length, *L*	10	(5 ± 1) mm/(0,200 ± 0,040) inch
4	tailstock	11	hydraulic pressure
5	tailstock alignment bolt	12	deflection, *D*
6	dial indicator, alternate for strain gauge (horizontal and vertical adjustment)	13	strain gauges
7	headstock	14	test joint (specimen separable joint)

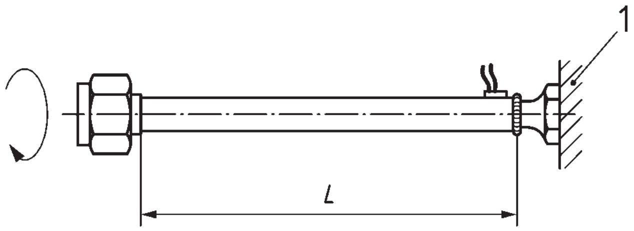
Figure 1 — Typical rotary flexure test schematic



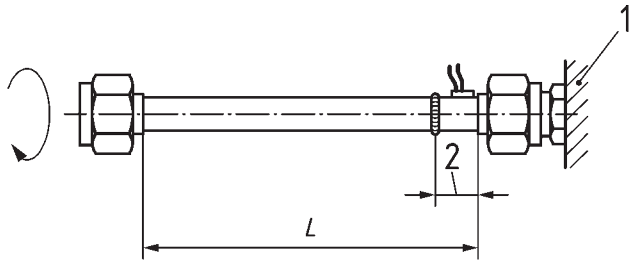
Key

1 tailstock
2 hydraulic pressure
3 accumulator to suit pressure
4 nitrogen pressure
5 actuator 2:1 ratio
6 laboratory test gauge, approximatively 35 000 kPa
7 laboratory test gauge, approximatively 14 000 kPa
8 needle valve
9 microswitch (to stop motor and cycle counter)

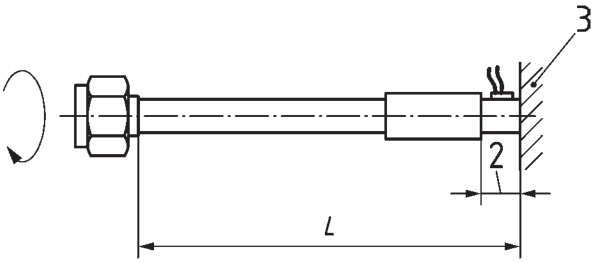
Figure 2 — Typical rotary flexure test hydraulic schematic



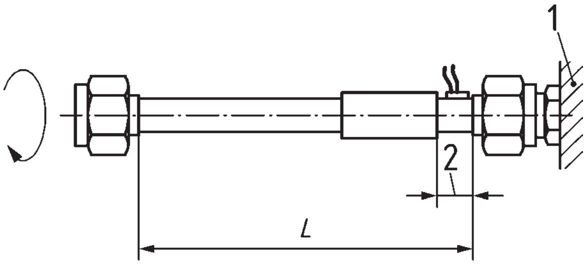
a) Permanent bulkhead union



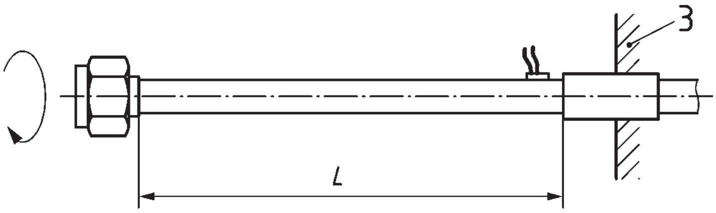
b) Buttweld



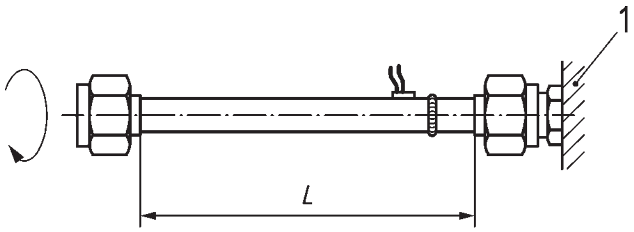
c) Permanent joint



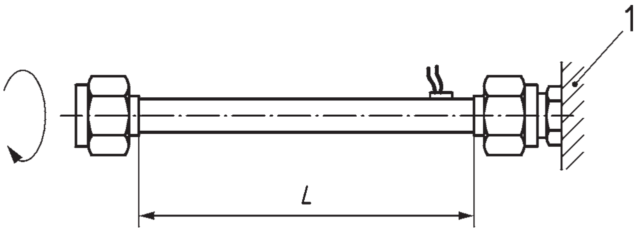
d) Permanent joint



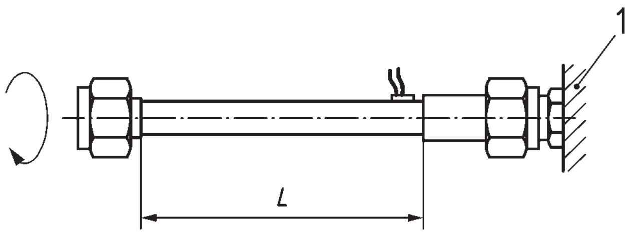
e) Permanent joint



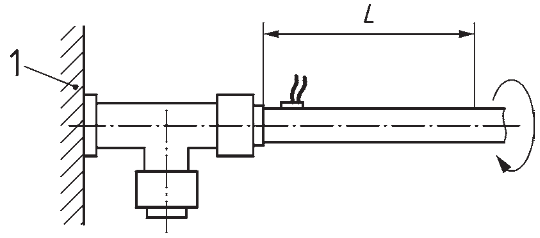
f) Reconnectable, butt welded joint



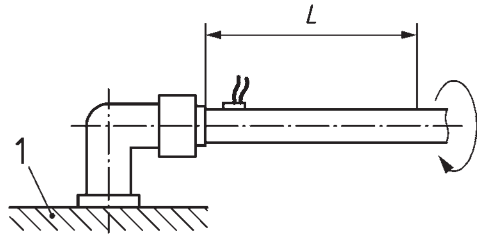
g) Reconnectable, internal swaged joint



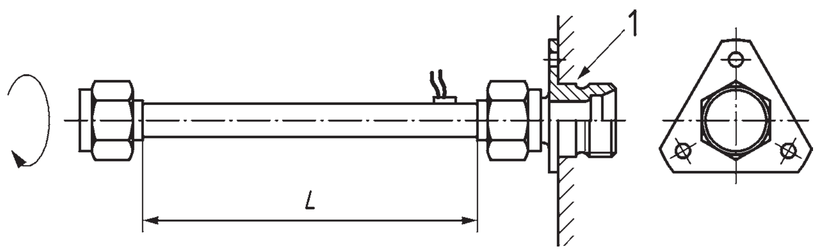
h) Reconnectable, external swaged joint



i) Reconnectable or permanent tee piece



j) Reconnectable or permanent elbow



k) Reconnectable union, flanged bulkhead

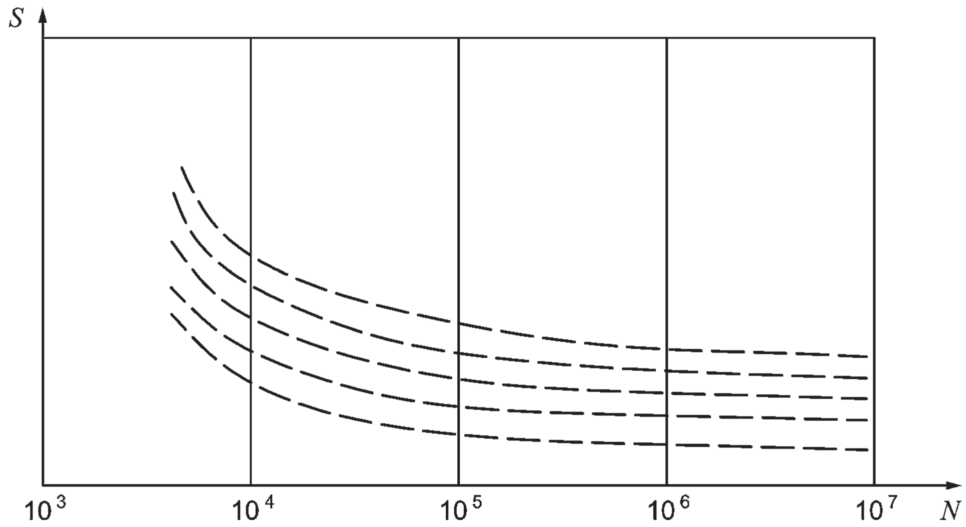
Key

1 boss

2 12 mm/0,500 inch max.

3 clamp

Figure 3 — Alternate specimen mounting for permanent joints



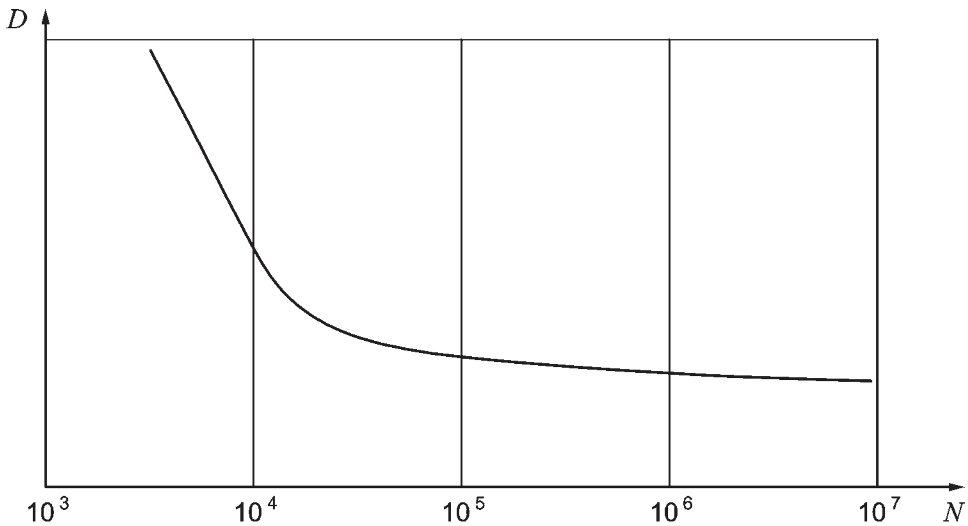
Key

S bending stress

N cycles to failure

NOTE Such curves could be established to illustrate possible observations in comparison testing of different materials or fitting attachments.

Figure 4 — *S*/*N* curves for characterizing various types of tubing or fitting joints



Key

D deflection

N cycles to failure

NOTE The correlation between the strain gauge reading and deflection may vary for different fitting designs. For example, a mechanically attached fitting may show some movement in the fitting, whereas a weld joint will be rigid. Also, a significant difference is noted if the *S*/*N* and *D*/*N* curves are compared for different tubing such as titanium alloy and corrosion resistant steel.

Figure 5 — *D*/*N* curve deflection/fatigue strength

2.3 Specimen length and deflection requirements

2.3.1 Specimen length

The length, *L*, of the specimens for rotary flexure testing shall be as shown in the Tables 1 and 2 and measured as shown in Figures 1 or 3, depending on the fitting design. For intermediate sizes, the length, *L,* may be interpolated from the tables.

2.3.2 Stress determination

The desired strain or bending stress level for each set of specimens is induced by deflection of the specimen in the headstock. The bending stress levels for the various deflection settings should be determined prior to applying pressure, using strain gauges and procedures as outlined in Clause 4. Strain gauges should always be used unless continual use of the same specimens and equipment makes settings by dial indicator acceptable. Such settings by dial indicator, however, shall be established in prior testing by the use of strain gauges. Strain gauges should be used whenever new test equipment is used. A typical stress cycle is illustrated in Figure 6.

2.3.3 Deflection

The specimen deflections required to induce the stress levels indicated in 3.2 are measured by dial indicator at the length, *L*, as shown in Figures 1 or 3.

Established deflection settings may be used in lieu of stress determination by strain gauge whenever qualification tests are being conducted, or when deflection plotting is of particular interest for example, to compare steel and titanium tubing.

2.4 Method of classification of fittings according to *S*/*N* flexure performance

Fitting/tubing combinations should be classified by the characteristic curves as shown in Figure 4, above which all *S*/*N* failure data points lie. Characteristic curves should be established as outlined in 3.2, showing cycles to failure for various bending stress levels.

2.5 Method of determining deflection/fatigue strength

Cycles to failure should be plotted as shown in Figure 5, showing cycles to failure for various deflection settings (deflection settings may correspond with bending stress levels used as outlined in 2.4).

NOTE Plotting of deflection in lieu of stress over cycles may be of interest to evaluate rigidity of fittings or compare the flexibility of different tubing materials such as corrosion-resistant steel and titanium.

Table 1 — Test specimen length (tube size)

Dimensions in millimetres

Tube size[a]	**DN 05**	**DN 06**	**DN 08**	**DN 10**	**DN 12**	**DN 14**	**DN 16**	**DN 18**	**DN 20**	**DN 22**	**DN 25**	**DN 28**	**DN 32**	**DN 40**
Length, *L*[b]	130	155	180	190	230	245	255	265	280	295	305	330	355	400

[a] Selected from ISO 2964. The "DN" designates nominal tube outside diameters, for example, DN 05 designates a 5-mm tube outside diameter.

[b] The length, *L,* may vary by ± 5 mm.

Table 2 — Test specimen length (dash size)

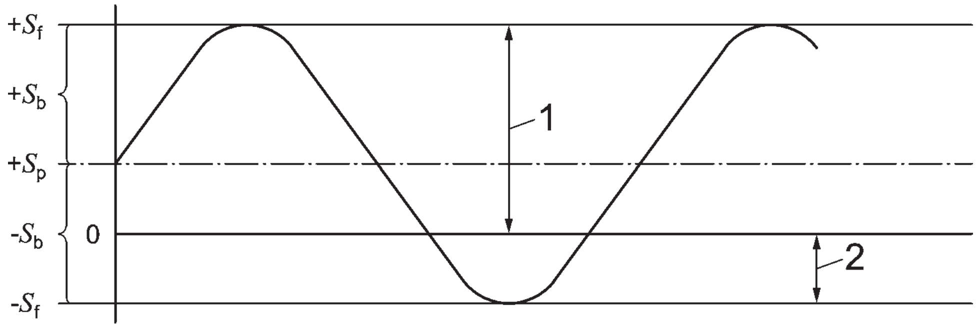
Dimensions in inches

Dash size[a]	**03**	**04**	**05**	**06**	**08**	**10**	**12**	**14**	**16**	**20**	**24**	**32**	**40**
Length, *L*[b]	5	6,25	7	7,5	9	10,75	11,5	12	12	14	15,25	[b]	[b]

[a] Selected from ISO 8575. Dash size 1/16 inch, example −05 = 5/16 inch diameter.

[b] Length shall be as specified by the user or procuring agency.

[c] The length, *L*, may vary by ± 0,2 inch.



Key

1 maximum stress

2 minimum stress

S_p mean axial stress produced by internal pressure

S_b stress caused by bending

S_f combined stress, $S_p + S_b$

Figure 6 — Typical alternating stress cycle with internal pressure

3 Procedure

3.1 Preparation for test

3.1.1 Instrumentation, strain gauges

Strain gauges should be mounted on each test specimen. The strain gauge type and location should be as follows:

Types: For tube size through DN 16/–10: approximately 4 mm (0,16 inch).

For tube sizes DN 20/–12 and above: approximately 8 mm (0,32 inch).

Location: The gauges should be mounted as shown in Figure 1, 90° apart.

NOTE Mounting of four gauges, in pairs, on the X and Y axis is optional.

3.1.2 Rotary flexure test set-up centring

The exact outside diameter and wall thickness of the test specimen should be measured and recorded before the test. It is also recommended to check straightness, and if not straight, to reject or at least to mark the specimen in the plane where the tube end is not aligned.

The tube assembly should be installed into the tailstock and the separate fittings hand tightened to permit subsequent adjustments. The setup procedure is detailed as follows.

— Free-state microstrain readings for the tube specimen should be measured and recorded prior to installation and tightening of the fitting nut.

— The self-aligning bearing at the headstock end should be roughly centred and the adapter inserted. The tailstock end should then be carefully tightened so as to avoid moving the test specimen out of line.

— The reconnectable joints shall be tightened to the required torque values.

— The symmetry of the specimen should be maintained during the tightening procedure with the assistance of one, preferably two, dial indicators positioned on the driven end of the tube. After tightening the adjustment bolts in the centred position, the symmetry shall be checked in the horizontal and vertical positions. While turning the headstock by hand, each dial indicator should indicate less than ±0,08 mm (±0,003 inch) nonsymmetrical deflection. For strain gauged specimens, the microstrain reading should deviate no more than ±20 microstrain from the free state microstrain reading referred to above.

— For each checking the headstock shaft may be moved back and forth in its bearing. The shaft will move freely for properly aligned specimens.

3.1.3 Flexure stress measurement

After the specimen is zeroed as described, the headstock should be initially adjusted to produce a strain gauge reading about 5 % below the required bending stress value. The machine should be briefly turned on up to stationary rpm and the dynamic reading (i.e. the maximum absolute value of the two strain gauges reading at full test revolutions per minute) recorded. This reading should be within ±10 microstrain of the test specified value or ±5 % of the targeted bending stress. Some readjustment is usually necessary.

3.1.4 Flexure deflection measurement

The deflection setting is measured by dial indicator as shown in Figure 1 and Tables 1 and 2.

3.1.5 Operating pressure

After the tube bending settings are completed by using the strain gauge (S/N) or dial indicator (D/N) methods described in Clause 2, the specified system pressure is introduced into the specimens.

3.2 S/N testing

3.2.1 A minimum of four sets of at least two specimens (specimen pairs) in each size should be subjected to flexure testing and the test results plotted on a semi-log plot, over a grid of S/N characteristic curves, as shown in Figure 4.

3.2.2 A bending stress of 35 % of the ultimate strength should be applied to the first set of specimens.

The bend stress settings should be made prior to applying system pressure, which is to be maintained until failure or completion of the test.

For low strength tubing (aluminium) a bending stress of 30 % of the ultimate strength should be applied for the first set of specimens.

3.2.3 If the failure point for the first set lies between 5 000 and 50 000 cycles, the bending stress should be reduced in increments of 5 %.

3.2.4 If the failure point for the second set lies between 200 000 and 1 million cycles, the bending stress should be lowered in increments of 2 %.

3.2.5 After two more sets of data points are plotted, an examination of the data will indicate the probable stress level for the last test sets. These levels should be selected to complete the *S/N* curve from, with the last test set completing or exceeding 10 million flexure cycles. At least three sets should fail at less than 10 million cycles.

After a failure, deflection and torque tightness of the fitting nut should be checked and recorded.

3.3 Deflection/fatigue testing

The same basic procedure should be followed as outlined in 3.2, except that the deflection settings are plotted over cycles to failure, as shown in Figure 5.

4 Formula

The total combined stress is calculated in Formula (1):

$$S = (e_{\max})(E) + \frac{Pd_i^2}{d_o^2 - d_i^2} \quad (1)$$

where

S maximum apparent total axial stress;

$e_{\max}$ maximum measured axial unit bending strain;

E modulus of elasticity for tube material;

P internal pressure;

d_o tube outside diameter;

d_i tube inside diameter.

5 Equipment

Suggested test fixtures: photographs of a suggested setup are shown in Figures 7 and 8.

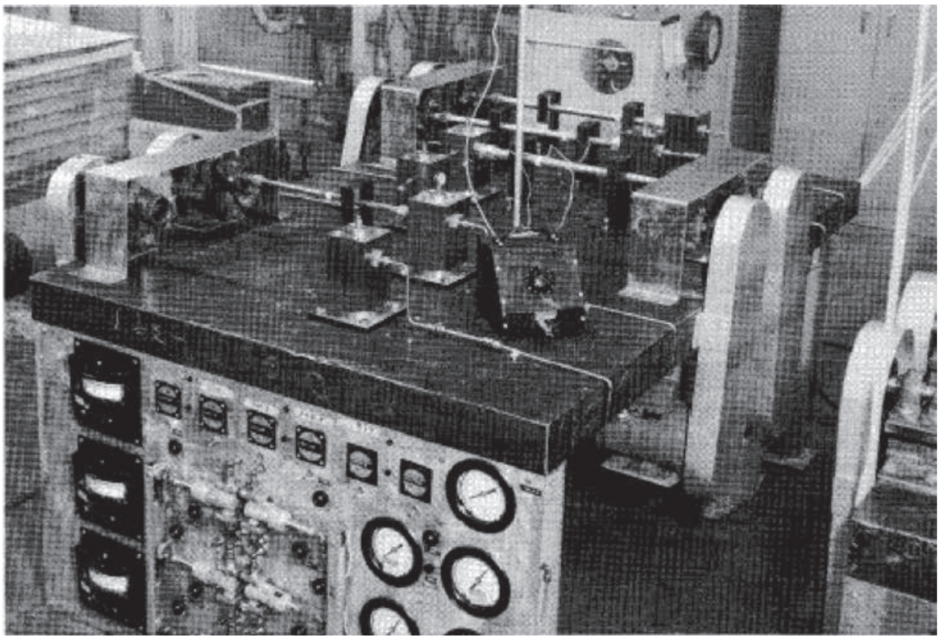


Figure 7 — Heavy-duty flexure device, tube sizes DN 20/–12 and upwards

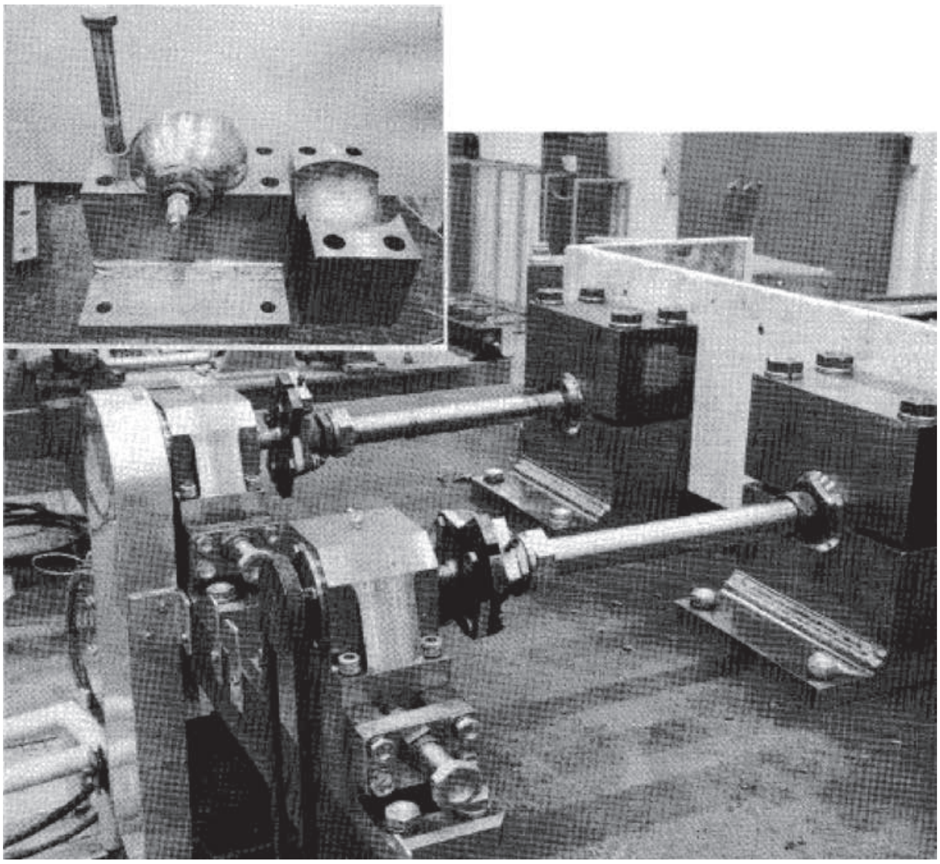


Figure 8 — Flexure test set-up for tube sizes up to DN 16/–10

Bibliography

[1] ISO 2964, *Aerospace — Tubing — Outside diameters and thicknesses — Metric dimensions*

[2] ISO 8575, *Aerospace — Tubing — Outside diameters and thicknesses — Inch dimensions*

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