



U-BEND FATIGUE TEST

PENFLEX TEST SUMMARY REPORT

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INTRODUCTION

1.1 PURPOSE

Conduct a U-Bend Test to compare the cycle life of single-braided annular and helical hose using ISO standards 10380:2012(E).

1.2 DESCRIPTION OF SAMPLES

Three stainless steel, single braided, annular hoses and three stainless steel, single braided, helical hoses (Table 1):

Quantity	Hose ID (in)	Length (ft)	Corrugation Type	Penflex Sample ID
3	¾	6	Helical	404-1HHB-012
3	¾	6	Annular	P3-H3021-B3004-012

Table 1

1.3 TEST PARAMETERS

U-Bend Test per ISO 10380:2012(E) Section 5.7 (See Appendix A). Penflex procedure included in Appendix B. Test parameters for each assembly (Table 2):

Penflex Sample ID	Test Pressure (PSI)	Pressure Medium	Dynamic R for U-Bend Testing- (mm)- 10380- 2012-type 1- 50	Dynamic R for U-Bend Testing- (in)- 10380- 2012-type 1- 50	Cycles/minute
404- 1HHB-012	300	Water	203	8.0	19
P3-H3021- B3004-012	300	Water	203	8.0	19

Table 2

1.4 REQUIRMENTS

No pressure drop in hose assembly or localized reduction of the hose radius more than 50% during the test.

TEST SUMMARY

2.1 RESULTS

The results of the cycle testing are summarized in Table 3:

Sample ID	Corrugation Type	Cycles	Termination Cause
404-1HHB-012	Helical	25,782	Pressure Drop
		33,730	Pressure Drop
		34,837	Pressure Drop
P3-H3021-B3004-012	Annular	235,991	Pressure Drop
		316,721	Pressure Drop
		343,738	Pressure Drop

Table 3

2.2 FAILIURE MODE



Figure 1: Annular hose at $\approx 115,000$ cycles

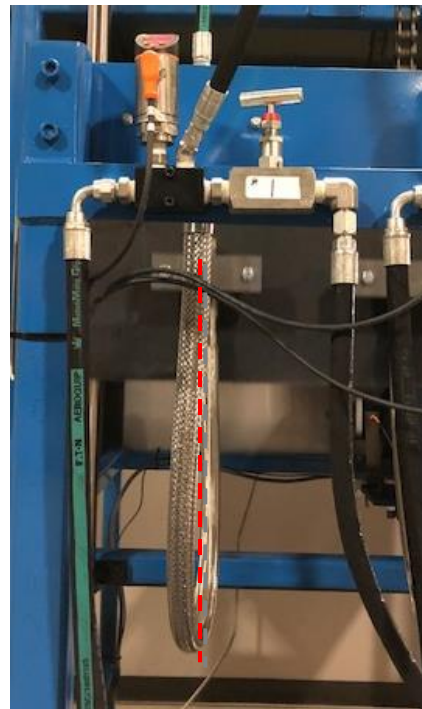


Figure 2: Helical hose at $\approx 20,000$ cycles

2.3 EXAMINATION

Figures 1 and 2 show the leak location for two test-samples. For helical hose, the cause of failure appears to be a stress fracture. For annular hose, the rubbing between the hose and braid slowly notched a hole into the surface.



Figure 3: Crack in Annular Hose

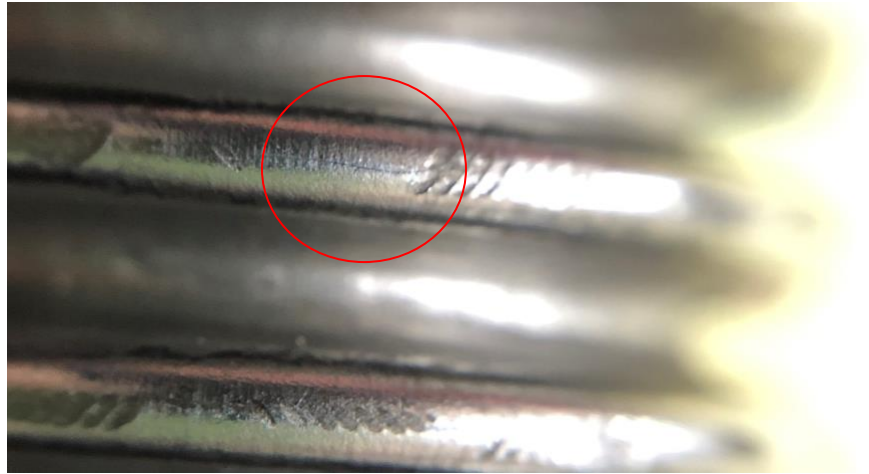
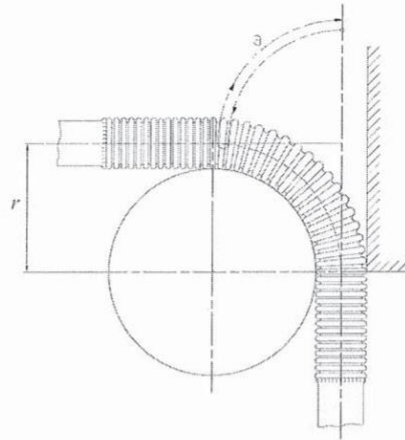


Figure 4: Crack in Helical Hose

Appendix A - ISO 10380:2012(E)

ISO 10380:2012(E)



b) Sample unbraided without outside protection

Key
 r bend radius
 a One cycle.

Figure 5 — Pliability test

5.7 Fatigue

5.7.1 General

Type 1 and type 2 corrugated metal hoses shall permit repeated flexing under pressure for reasonably expected life cycles of the product. The performance of the products shall be tested by representative cycle tests according to Table 7. Depending on the performance level, the cycle requirements shall be:

- Type 1-50: 50 000 cycles
- Type 1-10: 10 000 cycles
- Type 2-10: 10 000 cycles

Where tested in accordance with 5.7.2, high-cycle-life hoses shall have an average life of 50 000 cycles, but no sample below 40 000 cycles.

Where tested in accordance with 5.7.2, standard-cycle-life hoses shall have an average life of 10 000 cycles, but no sample below 8 000 cycles.

Table 7 — Requirements for fatigue

Hose type	Standard cycle 10 000 cycles	High cycle 50 000 cycles
1-50	—	x
1-10	x	—

Appendix A (Continued)

ISO 10380:2012(E)

Table 7 (continued)

Hose type	Standard cycle 10 000 cycles	High cycle 50 000 cycles
2-10	x	—
3	Pliable, no fatigue requirement	Pliable, no fatigue requirement

NOTE These representative cycle tests give a comparative quality level of the products and mostly do not allow direct reference to practical applications in the field. For very specific applications, the purchaser can consult the manufacturer about their specific experience or special tests.

5.7.2 Test requirements

The tests shall be conducted with the hose at the relevant maximum allowable pressure. The bench test shall be equipped with a leakage detection system allowing the identification of the occurrence of the leak during the test cycle. The bend radius shall be chosen from Table 8 and shall be recorded before the start of the test with the hose at the relevant maximum allowable pressure.

Table 8 — Bend radii for fatigue test

DN	Fatigue test	
	Types 1	Type 2
	Bend radius mm	
4	100	120
6	110	140
8	130	165
10	150	190
12	165	210
15	195	250
20	225	285
25	260	325
32	300	380
40	340	430
50	390	490
65	460	580
80	660	800
100	750	1000
125	1000	1250
150	1250	1550
200	1600	2000
250	2000	2500
300	2400	3000

NOTE The dimensions listed in this table can be used for design purposes; see the manufacturer for confirmation.

No lubricant shall be added before or during the test.

Failure shall be defined as

- leakage of the hose, and/or
- a localized reduction of the hose radius (as measured at the start of the test) of more than 50 % during the test.

Appendix A (Continued)

ISO 10380:2012(E)

5.7.2.1 Test for DN sizes up to and including DN 100 (U-bend test)

The test shall be conducted using metal hose assemblies mounted to form a vertical loop as shown in Figure 6. The active live length, l_L , of the assembly shall be as given in Formula (9).

The distance between the axes of the end fittings shall be equal to twice the bend radius (fatigue test) given in Table 8.

The metal hose assembly shall be subjected to repeated sinusoidal flexing at a rate of 5 cycles/min to 30 cycles/min in a direction parallel with the axis of the hose through a motion of $2x$ and where the active live length, l_L , is given by Formula (9):

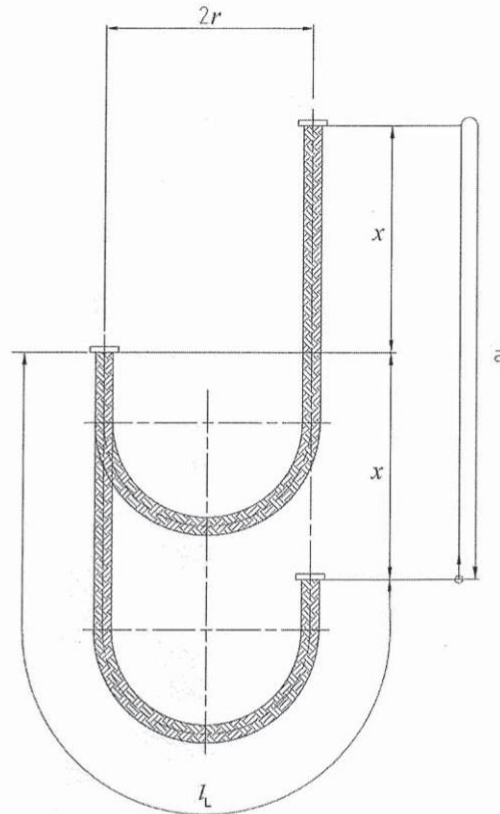
$$l_L = 4r + x \quad (9)$$

where

- | | |
|-----|--|
| r | is the bend radius, in millimetres (fatigue test); |
| x | is $4 \times \text{DN}$, in millimetres, or 125 mm, whichever is the greater; |
| DN | is the nominal size, in millimetres. |

Appendix A (Continued)

ISO 10380:2012(E)



Key
 x motion
 a One cycle.

Figure 6 — Fatigue test

5.7.2.2 Test for DN sizes over DN 100 (Cantilever bend test)

The metal hose assembly shall be rigidly fixed at one end as shown in Figure 7. The other end shall be moved by means of a lateral force, so that a lateral deflection, x , as given in Table 9, is achieved. The active live length, L_L , shall be six times the nominal size.

The hose shall be subjected to repeat sinusoidal flexing at a rate of 3 cycles/min to 15 cycles/min in a lateral direction to the axis of the hose.

Appendix B - Penflex U-Bend Test Procedure



FATIGUE TEST OF HOSE & BRAID ASSEMBLIES FOR EXPECTED LIFE CYCLES (U-bend test).

Objective: to set up and run cycle test machine for verifying expected life cycles of the corrugated hose and braid assemblies and their conformance to Type 2-10 Hoses ("standard-cycle-life hoses") per ISO 10380:2012(E).

This Instruction Applies to: Corrugated Hose Tester

1. Adjust dimensions of cycle test machine to match test radius R, spacing 2R and total travel T (per figure below, $T=a=2X$ up and 2x down) on data collection form (IN-PN-17F) for sample being tested.
2. Connect assembly to test machine. Verify set-up dimensions.
3. Pressurize assembly to Test Pressure on IN-PN-17F (+10%/-0). Record this pressure as ACTUAL TEST PRESSURE.
4. Zero the cycle counter.
5. Turn on the test machine.
6. Record the actual number of cycles/min being used (target 15-20 cycles/min.) Note that a cycle is counted as one full "UP and DOWN" through "back to starting point."
7. Observe the hose intermittently throughout the test. Look for "shape change" as the full-radius may begin to "square-off" Failure due to SHAPE CHANGE is when the radius in one of these corners becomes as small as $R/2$ (where R is the initial set-up radius being tested).
8. Record the number of cycles when the failure due to shape change occurs.
9. Continue the test until the assembly leaks (the machine should shut-off automatically at this point). Record the number of cycles at leakage.

Appendix C - Picture of Penflex U-Bend Tester

