

Contents

Page

Foreword	vii	
11.6	Submersible pump tests	1
11.6.1	Introduction	1
11.6.2	Test types	4
11.6.3	Test conditions	6
11.6.4	Definitions	6
11.6.5	Performance test	11
11.6.6	Hydrostatic test	20
11.6.7	Net positive suction head (NPSHR) test	24
11.6.8	Submersible motor integrity tests	29
11.6.9	Vibration test	32
11.6.10	Instrumentation	35
11.6.11	Model tests	43
Appendix A	Wire-to-water pump efficiency (informative)	45
A.1	Pump efficiency	45
A.2	Wire-to-water efficiency	46
A.3	Pump power and efficiency definitions and calculations	46
Appendix B	Sample problems and formulas (informative)	48
B.1	Affinity rules (rotodynamic pumps)	48
B.2	Calculated performance based on change in pump speed (metric units)	49
B.3	Calculated performance based on change in pump impeller diameter (US customary units)	50
B.4	Calculation of NPSHA on a wet-pit pump (metric units)	51
B.5	Calculation of NPSHA on a dry-pit pump (US customary units)	52
B.6	Sample calculation of performance tolerance bands for pump acceptance according to grade 1E and 2B (US customary units)	53
Appendix C	Determination, application, and calculation of instrument (systematic) uncertainty (informative)	55
C.1	Determination, application, and calculation of instrument (systematic) uncertainty	55
C.2	Distribution of probability	56
C.3	Examples of measurement uncertainty calculations	57
Appendix D	Conversion factors	67
Appendix E	Standards-setting organizations (informative)	69

Appendix F	Reporting of test results (informative)	70
F.1	Performance test report	70
Appendix G	Index	74

Figures

11.6.4.6a	— NPSH datum for horizontal pumps	8
11.6.4.6b	— NPSH datum for vertical pumps	8
11.6.5.2a	— Sample wet-pit performance test setup	13
11.6.5.2b	— Inlet submergence wet-pit test	13
11.6.5.2c	— Sample dry-pit performance test setup	14
11.6.5.4a	— Unilateral tolerance acceptance example	16
11.6.5.4b	— Bilateral tolerance acceptance example	16
11.6.5.4.2a	— Tolerance field for acceptance grades 1U and 2U	18
11.6.5.4.2b	— Tolerance field for acceptance grade 1E	18
11.6.5.4.2c	— Tolerance field for acceptance grades 1B, 2B, and 3B	18
11.6.5.5.2	— Pump performance (data plotted at test speed)	20
11.6.6.4	— Hydrostatic pressure test setup	21
11.6.7.2a	— Inlet throttling NPSHR test setup	25
11.6.7.2b	— Variable-lift NPSHR test setup	26
11.6.7.2c	— Closed-loop, dry-pit NPSHR test setup	26
11.6.7.2d	— Closed-loop, wet-pit NPSHR test setup	27
11.6.7.3a	— NPSH test with flow rate held constant	28
11.6.7.3b	— NPSH test with inlet head held constant	28
11.6.8.2.1	— Submersible motor integrity test setup using housing pressure test method	30
11.6.8.2.2	— Submersible motor integrity test setup using the housing vacuum test method	31
11.6.9.2.2	— Transducer location	33
11.6.9.4a	— Vibration limits (metric units)	34
11.6.9.4b	— Vibration limits (US customary units)	34
11.6.10.3.1a	— Requirements for static pressure tappings	40
11.6.10.3.1b	— Four pressure tappings connected by a ring manifold (grade 1)	41
11.6.10.3.1c	— One pressure tapping (general for grade 2 and 3)	41
11.6.10.3.2	— Gauge connectors	43
C.1	— Output signal vs. pressure value	64
F.1	— Sample pump test curve	71
F.2	— Pump test data sheet	73

Tables

11.6.1.3.1	— Symbols	3
11.6.1.3.2	— Subscripts	4
11.6.5.4	— Pump test acceptance grades and corresponding tolerance band	15
11.6.5.4.3	— Default acceptance grade	19

11.6.6.7 — Longer test periods	23
11.6.10.1.3 — Permissible amplitude of fluctuation as a percentage of mean value of quantity being measured.	35
11.6.10.1.4 — Maximum permissible measurement device uncertainty at guarantee point	36
11.6.10.1.6 — Instrument recalibration maximum intervals	37
11.6.10.2.1a — Straight pipe required before a venturi meter in diameters of pipe.	38
11.6.10.2.1b — Straight pipe required before a nozzle or orifice plate in diameters of pipe	38
11.6.10.2.1c — Straight pipe downstream of pressure tap of a nozzle or orifice plate meter in diameters of pipe.	39
C.1 — Lab pressure calibrator calibration data	58
C.3 — Lab precision DC current measurement device calibration data	59
C.2 — Published accuracy of lab calibration devices	59
C.5 — Pressure transducer calibration	60
C.4 — Lab DC current source calibration data	60
C.6 — DA system current measurement module (output) calibration data	61
C.7 — Calculation of percent uncertainty for the discharge pressure, full system of 300-psi pressure transducer and data acquisition system	62
C.8 — Differential pressure transducer information.	63
C.9 — Signal measurement device information.	63
C.10 — Venturi information - BIF 2-in s/n 12345	63
C.11 — Differential pressure transducer calibration data	64
C.12 — Differential pressure transducer calibration data analysis	64
C.13 — Venturi flowmeter calibration data and analysis	65
C.14 — Calculation of individual device uncertainty and total uncertainty.	66
D.1 — Conversion factors	67