

DIN 19704-1:2014-11 (E)

Hydraulic steel structures - Part 1: Criteria for design and calculation

| Contents | | Page |
|-----------------|--|-------------|
| Foreword | | 5 |
| 1 | Scope | 6 |
| 2 | Normative references | 6 |
| 3 | Documentation | 9 |
| 3.1 | For steel structures | 9 |
| 3.2 | For machinery | 10 |
| 4 | Materials | 10 |
| 4.1 | Materials for steel structures | 10 |
| 4.2 | Sealant materials | 11 |
| 4.2.1 | Elastomers | 11 |
| 4.2.2 | Plastics | 12 |
| 4.2.3 | Non-ferrous metals | 12 |
| 4.3 | Machinery | 12 |
| 5 | Characteristic values for actions on steel structures | 12 |
| 5.1 | Permanent actions | 12 |
| 5.2 | Variable actions | 13 |
| 5.2.1 | Hydrostatic actions | 13 |
| 5.2.2 | Hydrodynamic actions | 13 |
| 5.2.3 | Hydrodynamic actions with moving gate | 13 |
| 5.2.4 | Ice loads | 13 |
| 5.2.5 | Ice pressure | 14 |
| 5.2.6 | Imposed loads | 15 |
| 5.2.7 | Inertial forces | 15 |
| 5.2.8 | Changes in support conditions | 15 |
| 5.2.9 | Thermal effects | 15 |
| 5.2.10 | Ship friction | 15 |
| 5.2.11 | Ship impacts | 16 |
| 5.2.12 | Wind loads | 16 |
| 5.2.13 | Tow-rope pulling forces on bollards | 16 |
| 5.2.14 | Transportation, assembly and maintenance conditions | 16 |
| 5.2.15 | Pressure of fresh concrete | 16 |
| 5.2.16 | Other actions | 16 |
| 5.3 | Accidental actions | 16 |
| 5.3.1 | Loss of uplift due to leakage in the air chambers | 16 |
| 5.3.2 | Drive action in the case of a failure | 17 |
| 5.3.3 | Earthquakes | 17 |
| 5.4 | Gates with double-acting drive | 17 |
| 5.5 | Blockage by foreign bodies | 17 |
| 6 | Friction | 17 |
| 6.1 | General | 17 |
| 6.2 | Sliding friction | 17 |
| 6.3 | Static friction | 18 |
| 6.4 | Rolling friction | 18 |
| 6.4.1 | Rolling bearings | 18 |
| 6.4.2 | Wheels on rails | 18 |
| 6.4.3 | Wheel flange friction | 18 |

| | | |
|-----------|---|-----------|
| 7 | Calculations for steel structures | 19 |
| 7.1 | Required analyses | 19 |
| 7.2 | Calculation of stresses | 20 |
| 7.3 | Analysis procedure | 22 |
| 7.4 | Ultimate limit states | 22 |
| 7.4.1 | General | 22 |
| 7.4.2 | Stability analysis | 22 |
| 7.4.3 | Verification of static equilibrium | 23 |
| 7.5 | Serviceability limit states | 23 |
| 7.5.1 | General information | 23 |
| 7.5.2 | Deformations | 23 |
| 7.5.3 | Closing pressure | 23 |
| 7.6 | Fatigue | 23 |
| 7.6.1 | General information | 23 |
| 7.6.2 | Partial safety factors for fatigue verification | 24 |
| 7.7 | Further provisions for particular building types and structural members | 24 |
| 7.7.1 | Beams with wide flanges | 24 |
| 7.7.2 | Design of plates subjected to bending loads | 24 |
| 7.7.3 | Cut-outs in plates | 24 |
| 7.7.4 | Rails | 24 |
| 8 | Characteristic values for actions on machinery | 26 |
| 8.1 | General | 26 |
| 8.2 | Determining drive forces | 27 |
| 8.3 | Drive power | 27 |
| 8.4 | Characteristic values of maximum transmitted forces | 28 |
| 8.5 | Oil-hydraulic drives | 28 |
| 8.5.1 | Basis of calculation | 28 |
| 8.5.2 | Determining design operating pressures | 28 |
| 8.5.3 | Determining static pressure in the hydraulic cylinder or motor | 30 |
| 8.5.4 | Oil pressure limit values | 30 |
| 8.5.5 | Pressure limiter | 31 |
| 9 | Machinery design | 31 |
| 9.1 | General | 31 |
| 9.2 | Required analyses | 31 |
| 9.3 | Stress analysis | 31 |
| 9.4 | Calculation of resistances | 32 |
| 9.5 | Ultimate limit state verification | 33 |
| 9.5.1 | Verification of stresses under static loading | 33 |
| 9.5.2 | Stability verification | 33 |
| 9.5.3 | Fatigue verification | 33 |
| 9.5.4 | Analysis of serviceability limit state | 35 |
| 10 | Calculations for special machine components | 35 |
| 10.1 | General | 35 |
| 10.2 | Hydraulic cylinders and electric lifting cylinders | 36 |
| 10.2.1 | Verification by calculation | 36 |
| 10.2.2 | Hydraulic cylinders | 36 |
| 10.2.3 | Electric lifting cylinders | 36 |
| 10.2.4 | Analysis of buckling strength | 37 |
| 10.2.5 | Fatigue verification | 37 |
| 10.3 | Hydraulic pipes | 37 |
| 10.4 | Hydraulic components | 37 |
| 10.5 | Electric motors | 38 |
| 10.6 | Brakes | 38 |
| 10.7 | Couplings | 38 |
| 10.8 | Shafts | 38 |
| 10.9 | Shaft-to-hub connections | 38 |
| 10.9.1 | Keyed shafts and splines | 38 |
| 10.9.2 | Interference fits | 39 |

| | | |
|---|---|----|
| 10.9.3 | Involute spline joints..... | 39 |
| 10.9.4 | Ring cone locking assemblies..... | 39 |
| 10.10 | Toothed gearing..... | 39 |
| 10.11 | Worm gearing | 40 |
| 10.12 | Plain bearings made from non-ferrous casting alloys | 40 |
| 10.13 | Plain bearings made from composite material with solid lubricant..... | 41 |
| 10.14 | Spherical plain bearings and pintle bearings | 42 |
| 10.15 | Eye bars, chain link plates and eye plates | 42 |
| 10.16 | Chain joints | 43 |
| 10.17 | Rod ends..... | 44 |
| 10.18 | Pinion racks, pinion chains and gear racks | 44 |
| 10.19 | Rolling bearings | 44 |
| 10.20 | Rope drives | 44 |
| 10.21 | Rope wheels, rope drums and compensating rollers..... | 45 |
| 10.22 | Wheels, guide rollers, mitre gates and rails | 45 |
| 10.22.1 | General | 45 |
| 10.22.2 | Verification of static strength..... | 46 |
| 10.22.3 | Fatigue verification..... | 47 |
| 10.22.4 | Components with deposit welding..... | 48 |
| 10.22.5 | Geometrical requirements | 48 |
| 10.23 | Axles and hinge bolts..... | 48 |
| 10.24 | Helical springs | 49 |
| 10.25 | Disc springs..... | 49 |
| 10.26 | Fasteners..... | 49 |
| Annex A (normative) Basic criteria for fatigue verification | | 50 |
| A.1 | General information | 50 |
| A.2 | Gates in inland waters | 50 |
| A.2.1 | Lock gates | 50 |
| A.2.2 | Ship lift gates..... | 50 |
| A.2.3 | Ship lift troughs..... | 50 |
| A.2.4 | Weir gates..... | 50 |
| A.2.5 | Flood gates and safety gates | 50 |
| A.2.6 | Gates of pumping stations | 51 |
| A.3 | Gates in coastal waters | 51 |
| A.3.1 | Tidal range | 51 |
| A.3.2 | Sea lock gates | 51 |
| A.3.3 | Flood gates and barrage gates | 51 |
| A.4 | Gates of dams and hydroelectric power plants | 51 |
| Bibliography | | 52 |