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Steel Pipes of Large Diameter Subject to Heavy Internal Pressure.

Stahlrohre für Druckleitungen mit großem Durchmesser und hohem Innendruck.

Tuyaux en acier pour conduites forcées de grand diamètre, sous de hautes pressions intérieures.

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It has been found possible to obtain valuable information as to the distribution of stresses and strains, and to arrive at the factors of safety enumerated below, by means of tests carried out in the Swiss Federal Laboratory for Testing Materials during the years 1930 to 1935. The tests were carried through until the pipes burst under the effect of the internal pressure and they were correlated with extensive tests and investigations of actual pipe lines as well as of the materials employed. Diameter $D = 1.8 — 4.6$ m; pressure head H up to 1750 m; coefficient of capacity $H \cdot D^2 = 1500 — 3000$:

Type	Factors of safety as calculated		
	for static failure	for yield	fatigue rupture
1. Welded pipes with normal or helical welds, "Sulzer Winterthur"			
Normal quality steel, tensile strength $\beta z = 38—42$ kg/mm²	3.5	2.4	1.6
High quality steel, tensile strength $\beta z = 42—48$ kg/mm²	3.5	2.4	1.4
2. Hot bound pipes, "Ferrum" Katowice Tensile strengths $\beta z \cong 38$ kg/mm² in pipes $\beta z \cong 60$ kg/mm² in binding	3.4	2.3	—
3. Cold drawn, previously bound pipes, "Autofrettage G. Ferrand" by Bouchayer et Viallet, Grenoble Tensile strengths $\beta z \cong 38$ kg/mm² in pipes $\beta z \cong 94$ kg/mm² in binding	3.9	2.0	—
4. Pipes bound with steel wire from a reel, "Monteux", Paris Tensile strengths $\beta z \cong 42$ kg/mm² in pipes $\beta z \cong 197$ kg/mm² in binding	4.5	2.0	—

The four types which were subjected to close investigation are found to compete with one another technically and economically, and the helical welding is seen to make the competition keener. Each type offers technical and economic advantages of its own — whether with respect to weight, freedom from rusting, maintenance or safety — which require to be established by careful comparative experiments in each particular case.

As regards complicated shapes such as branches, junctions, inlets to turbines, large manholes, and sockets an accurate estimate of the true conditions of stress and safety can be obtained merely by measuring the stresses and strains under a multi-axial system of loading. Further valuable information can be obtained from a study of crack formation and lines of flow in specially applied coatings of lacquer. Fatigue tests and photo-elastic experiments offer means of estimating reductions in concentrations of stress.

The system of stresses and strains corresponding to the operating pressure must nowhere reach the yield value. Nothing but a combined application of all these methods of testing, in a perfected form, will allow the effective degree of safety of pressure pipe lines to be correctly assessed.

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