DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
WASHINGTON

January 26, 1934

TESTING MACHINES
for
Determining the Strength and Other Properties
of
Engineering Materials
in the laboratories
of
The National Bureau of Standards
Department of Commerce
Washington, D.C.

The Bureau of Standards frequently receives inquiries concerning different types and makes of testing machines and devices for calibrating testing machines.

This letter circular lists the machines and calibrating devices in the Bureau's laboratories and summarizes the experience of the staff with each type.

The list includes only tension, compression, and transverse testing machines having capacities of 2000 pounds or more. It does not include the machines used for measuring hardness, impact resistance, torsional properties, etc. A few special testing machines which are not commercially manufactured have also been omitted.

TYPES OF TESTING MACHINES

Type A, Beam and poise, screw machines

The load on the specimen is applied by one platen of the machine which is moved by screws. These screws are driven through gearing either manually or by a motor. The other platen of the machine is supported upon a system of levers having knife-edge bearings. The lever system includes a graduated weigh-beam upon which a poise is moved manually. When the beam is balanced the magnitude of the load is indicated by the position of the poise on the beam.

Type B, Beam and poise, hydraulic machines

The load on the specimen is applied by one platen of the machine which is moved by a hydraulic jack having a packing. This jack is connected hydraulically to a fluid support having a flexible diaphragm. The fluid support is connected mechanically through a system of levers having knife-edge bearings to a graduated weigh-beam upon which a poise is moved manually. When the beam is balanced the magnitude of the load is indicated by the position of the poise on the beam.

Type C, Bourdon tube, hydraulic machines

The load on the specimen is applied by one platen of the machine which is moved by a hydraulic jack having a packing. This jack is connected hydraulically to a Bourdon tube pressure gage having a pointer which automatically moves around a graduated circular dial. At all times the magnitude of the load is indicated automatically by the position of the pointer on the dial.

Type D, Pendulum, hydraulic machines

The load on the specimen is applied by one platen of the machine which is moved by a hydraulic jack having no packing. This jack is connected hydraulically to a small jack, the piston of which is rotated continuously to eliminate friction. The piston of the small jack is connected mechanically to a weighted pendulum. The force exerted by this piston deflects the pendulum from its vertical position. The pendulum is connected mechanically to a pointer which automatically moves around a graduated circular dial. At all times the magnitude of the load is indicated automatically by the position of the pointer on the dial.

Type E, Fluid-support, Bourdon-tube, hydraulic machines

The load on the specimen is applied by one platen of the machine which is moved by a hydraulic jack having a packing. The force exerted by the specimen on the other platen is transmitted directly to a fluid support as a compressive force. The fluid support having a flexible diaphragm is connected hydraulically to a Bourdon tube pressure gage having a pointer which automatically moves around a graduated circular dial. There is no hydraulic connection between the jack and the fluid support with pressure gage. At all times the magnitude of the load is indicated automatically by the position of the pointer on the dial.

Type F, Fluid-support, weighing-scale, hydraulic machines

The load on the specimen is applied by one platen of the machine which is moved by a hydraulic jack having a packing. The force exerted by the specimen on the other platen is transmitted directly to a fluid support as a compressive force. The fluid support having a flexible diaphragm is connected hydraulically to a weighing scale. This scale has a small fluid support having a flexible diaphragm. This small support is connected mechanically to a weigh-beam having fulcrum-plate bearings. Weights may be applied or removed from the beam by manually operated levers. For small loads the beam, also, is provided with a poise which is moved manually. There is no hydraulic connection between the jack and the fluid support with weighing scale. When the beam is balanced the load is indicated by numerals which automatically appear in the weighing scale or by the position of the poise on the beam.

TYPES OF CALIBRATING DEVICES

Type G, Dead-weight calibrating machines

These machines are used for calibrating proving devices such as elastic bars, calibrating boxes, proving rings, etc. After calibration these devices are used to determine the error in the load indicated by testing machines. These dead-weight machines are not suitable for loading specimens to rupture.

The load on the device to be calibrated is applied by one platen of the machine which is moved by a hydraulic jack having a packing or by screws driven through gearing either manually or by a motor.

The force exerted by the device on the other platen raises masses of metal. The sum of the weights of all the masses of metal which have been raised is the load. The difference between the actual weight of each mass of metal and the nominal weight does not exceed 1/50 of one per cent. The load is indicated automatically by rods which by their vertical position show which masses of metal have been raised.

Type H, Proving rings

The proving ring is a heat-treated steel ring having projections or bosses on a diametrical axis. The load is applied to the external bosses and the deflection-measuring apparatus to the internal bosses. The deflection-measuring apparatus consists of a screw micrometer and a vibrating reed. When a load is applied to the ring it deflects. The deflection is measured by the micrometer and reed.

Type I, Calibrating boxes

The calibrating box is a cylindrical steel chamber filled with mercury and having extensions on each end to which the load is applied. The change in the volume of the vessel caused by the load is indicated by the reading of a screw micrometer, the end of which projects into the chamber, displacing sufficient mercury to compensate for the change in volume.

MAKERS

The names and addresses of the makers of the testing machines in the Bureau's laboratories are given below:

Amsler - Alfred J. Amsler and Company, Schaffhausen, Switzerland

Representative - Herman A. Holz,
167 East 33rd St.,
New York, N. Y.

MAKERS, Cont.

Baldwin-Southwark - Baldwin-Southwark Corporation,
Paschall Station Post Office,
Philadelphia, Pa.

Emery - A. H. Emery Company,
682 Main Street,
Stamford, Conn.

Olsen - Tinius Olsen Testing Machine Company,
500 North Twelfth Street,
Philadelphia, Pa.

Riehle - Riehle Brothers Testing Machine Company,
1424 North Ninth Street,
Philadelphia, Pa.

The names and addresses of the makers of the calibrating devices for testing machines which have been calibrated in the Bureau's laboratories are given below:

Amsler - Alfred J. Amsler and Company (calibrating boxes)
Schaffhausen, Switzerland.

Representative - Herman A. Holz,
167 East 33rd Street,
New York, N. Y.

Emery - A. H. Emery Company, (dead-weight machines)
682 Main Street,
Stamford, Conn.

Morehouse - Morehouse Machine Company, (proving rings)
233 West Market Street,
York, Pennsylvania.

Olsen - Tinius Olsen Testing Machine Co., (proving rings)
500 North Twelfth Street,
Philadelphia, Pa.

LIST OF TESTING MACHINES AND CALIBRATING DEVICES IN THE BUREAU OF STANDARDS LABORATORIES

Reference No.	Capacity lb	Bureau of Standards Division	Maker	Remarks
		Testing Machines		
		Type A		
A-1	2,000	IX	Riehle	Tension or compression
A-2	10,000	VIII	"	" " "
A-3	20,000	VI-5	Olsen	" " "
A-4	20,000	IX	"	Compression only
A-5[a]	20,000	IX	"	" "
A-6	50,000	VI-5	"	Tension or compression
A-7	50,000	VI-5	Riehle	" " "
A-8	50,000	IX	"	" " "
A-9	100,000	VI-5	"	" " "
A-10	100,000	VIII	"	" " "
A-11[b]	100,000	IX	Olsen	" " "
A-12	100,000	IX	Riehle	" " "
A-13[c]	200,000	IX	Olsen	" " "
A-14	200,000	IX	Riehle	" " "
A-15	300,000	IX	"	" " "
A-16	600,000	VI-5	Olsen	" " "
		Type B		
B-1	10,000,000	VI-5	Olsen	Compression only
		Type C		
C-1[c]	100,000	IX	Olsen	Compression ohly
C-2	1,000,000	III-6	Riehle	" "
		Type D		
D-1	50,000	VIII	Amsler	Tension or compression
D-2	100,000	VI-5	"	" " "
D-3	100,000	VI-5	"	Tension only (rope)
		Type E		
E-1	100,000	VI-5	Baldwin-Southwark (Emery-Tatnall)	Tension or compression
E-2	300,000	IX	" "	Compression only
E-3[c]	4,000,000	IX	" "	" "

[a] Branch laboratory, Northampton, Pa.
[b] Branch laboratory, San Francisco, Cal.
[c] Branch laboratory, Denver, Colo.

LIST OF TESTING MACHINES AND CALIBRATING DEVICES
IN THE BUREAU OF STANDARDS LABORATORIES, (Continued)

Reference No.	Capacity	Bureau of Standards Division	Maker	Remarks
	lb			
	Testing Machines, (Continued)			
	Type F			
F-1	230,000	VI-5	Emery	Tension or compression
F-2	1,150,000	VI-5	"	Tension
	2,300,000			Compression
	Calibrating Devices			
	Type G			
G-1	10,100	VI-5	Emery	Tension or compression by 100 lb increments
G-2	111,000	VI-5	Emery	Tension or compression by 1000 lb increments
	Type H			
H-1	6,000	VI-2	Morehouse	Tension only
H-2	6,614 (3000 kg)	VI-5	"	Compression only
H-3	10,000	VI-5	"	" "
H-4	50,000	VI-5	"	" "
H-5	50,000	IX	"	" "
H-6	100,000	VI-5	"	" "
H-7	100,000	VI-5	"	" "
H-8	100,000	VI-5	"	" "
H-9	300,000	VI-5	"	" "
H-10	300,000	VI-5	"	" "
H-11	300,000	VI-5	"	" "
	Type I			
I-1	70,000	VI-5	Amsler	Tension or compression
I-2	250,000	VI-5	"	Compression only

SUMMARY

This summary gives the experience of the Bureau of Standards' staff with testing machines and calibrating devices of each type in the Bureau laboratories.

Cost, etc. The cost, dimensions (floor space), and weight of a testing machine of a particular type may be obtained from the maker by anyone interested.

Power required. The Bureau has never determined the power required to operate testing machines of different types. Most testing machines are not operated continuously during working hours.

It is believed that differences in the cost of the power required by testing machines of different types should not be given much weight when selecting a testing machine.

Maintenance. The Bureau has never noticed any appreciable difference in the cost of maintaining testing machines of different types. When operated by a reasonably competent staff, each of the types in its laboratories has given satisfactory service and the cost of repairs and renewals has been negligible.

For types B, C, E, and F, machines in which the load is applied by a hydraulic jack having a packing: The Bureau has seldom found it necessary to replace the packing in the jack. These packings have given satisfactory service for many years.

For types E and F, machines with fluid supports having flexible diaphragms: The Bureau has found it necessary to replace a diaphragm only on testing machine Reference No. E-3.

Load indication. For machines of types A, B, and F having a beam with poise or weights the indicated load is not the load on the specimen unless the beam is balanced. The poise must be moved manually on the machines of these types in the Bureau laboratories. This requires the attention of the operator. If the load is changing rapidly, experience shows that it is impracticable for the operator to keep the beam balanced. The Bureau has had little experience with machines which automatically move the poise to balance the beam.

For machines of types C, D, and E having dials upon which the load is indicated automatically by the position of the pointer, no attention on the part of the operator is required. The indicated load at all times is the load on the specimen even if the load is changing rapidly. The error in the indicated load due to the rate of change of the load is believed to be negligible for the rates used in testing engineering materials.

For the machines of types A, D, E, F, and G, experience does not indicate that there is any appreciable difference in the indicated load whether the load is increasing or decreasing, whether the weigh-beam (if any) is moving upward or downward, whether the piston of the hydraulic jack (if any) or the fluid support (if any) is moving out of the cylinder or moving into the cylinder or whether the dead-weights (if any) are moving upward or downward.

For the machines of types B and C having hydraulic jacks with packing, experience indicates that there is a considerable difference in the indicated load when the piston is moving out of the cylinder and when it is moving into the cylinder. When the piston is moving out of the cylinder, the friction of the packing, in so far as this Bureau has been able to determine, is nearly constant for a given load over a long period of time (several years). Assuming that this friction is proportional to the load (and therefore to the pressure in the jack) these machines are adjusted so that the indicated load is very nearly the load on the specimen, when the piston is moving out of the cylinder.

For proving rings type H and calibration boxes type I, there is an appreciable difference in the load indicated by the device when the load is increasing and when it is decreasing. This difference is due to the elastic properties of the material from which the device is made. These devices are usually calibrated under increasing loads and when so calibrated they should be used for calibrating testing machines under increasing loads only.

Rate of applying load. The properties of a material determined from the results of tests depend somewhat upon the rate at which the load is applied. Although the rate of loading may be expressed either as the rate of increase in the stress (lb per sq in) with respect to time or as the rate of increase in the strain (in.per in.) with respect to time, the Bureau has found it more convenient to express the rate of loading as the rate of increase in stress. The Bureau loads concrete cylinders at a definite rate (lb per sq in. per min) when determining the compressive strength. For the hydraulic machines in the Bureau laboratories of types C, D, and E having dials upon which the load is indicated automatically, the rate of loading may be determined readily by observing the position of the pointer at uniform intervals of time. The rate may easily be changed by very small increments by adjusting the controls to obtain the desired rate of loading. Some of these machines are provided with a pacing pointer which moves around the dial at the desired rate of loading. The operator has only to operate the controls so that the load-indicating pointer coincides with the pacing pointer.

For machines which are not provided with a pacing pointer the Bureau has found it convenient to use a metronome giving audible signals at predetermined intervals of time. The operator has only to watch the dial , listen to the signals, and adjust the controls.

For the machines of types A, B, and F having a beam with poise or weights it has been found impracticable for one operator to accurately determine the rate of loading, due to the necessity for keeping the beam balanced manually, observing the indicated load and observing the time. For the machines of type A it is, in many cases, impossible to obtain the desired rate of loading because the speed of the moving platen is restricted to one of those obtainable with the gear changes provided.

Sometimes the speed of the moving platen is determined instead of the rate of loading. It is believed that this speed depends somewhat upon the load; therefore, this speed, usually measured when there is no load on the machine, may differ appreciably from the speed under load. The speed of the moving platen bears no constant relation to the rate of loading because of slipping of the grips, deformation of the fixtures for loading the specimen, etc. To obtain the desired speed of the moving platen the Bureau has found it necessary to provide the electric motors of many of the machines of type A with multiple-step electrical resistances because the number of speed changes (gear shifts) did not give the desired speeds.

Experience in the Bureau laboratories emphasizes the importance of having testing machines which allow the rate of loading to be accurately determined and which allow the rate to be easily and quickly varied by very small increments.

Accuracy. We believe that every testing machine (except dead-weight machines) should be calibrated to capacity at intervals not exceeding one year. Satisfactory methods for determining the error of loads above 900,000 lb are not available in the Bureau laboratories. Therefore, few calibrations for greater loads have been made. Although machines of type A might be expected to require calibration less frequently than other types the Bureau has no definite information which shows any differences between types. With the exception of machines of types B and C, it has had no difficulty in maintaining each of the machines in its laboratories so that between ten per cent of capacity and capacity (if the capacity does not exceed 900,000 pounds) the errors in the indicated loads do not exceed one per cent. For the machines of types B and C it is believed that the errors in the indicated loads do not exceed three per cent for the loads for which these machines are used.

Proving rings. Proving rings which when calibrated in the Bureau's laboratories were found to comply with the Bureau of Standards Letter Circular 294, "Specifications for Proving Rings for Calibrating Testing Machines" and for which Bureau of Standards certificates have been issued have been made by:

The Morehouse Machine Company, 233 West Market Street, York, Pennsylvania

The Tinius Olsen Testing Machine Company, 500 North 12th Street, Philadelphia, Pennsylvania