DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
George K. Burgess, Director

SPECIFICATION FOR HAND-OPERATED GRAIN HOPPER SCALES

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I. INTRODUCTION

During a period of about one and one-half years following the issuance of Interstate Commerce Commission Docket 9009, entitled, "Claims for Loss and Damage of Grain," it developed that many authorities placed different interpretations upon various parts of that report, especially in relation to grain hopper scales. It was also noted that there were slight differences in the specifications of design between these contained in this report and those followed by the scale manufacturers.

Because of these uncertainties, a joint conference of all bodies essentially interested was suggested for the purpose of harmonizing interpretations and ideas. Such a joint conference was called by H. A. Foss, chairman of the Weighmasters'-Scale Men's Conference. The first meeting was held June 24, 1921. Several later meetings were held and the specifications appearing herein were finally adopted.

These specifications have been under consideration by the Interstate Commerce Commission and an informal approval of them is embodied in a letter of June 9, 1923, signed by Commissioner B. H. Meyer, chairman, to Henry L. Goeman, chairman transportation committee, Grain Dealers National Association, which says in part:

It appearing that these amended specifications as modified and approved by the United States Bureau of Standards are acceptable to the principal parties at interest, and that standard specifications are in the interests of both shippers

and carriers, we see no reason for withholding our tentative indorsement of the specifications as thus modified. This letter may, therefore, be considered as indicating our informal approval thereof, with the understanding that such approval is subject to such modification, if any, as may appear to be proper as a result of any formal proceeding which may hereafter be instituted before us.

Representatives of the following bodies participated in the conference upon which the following recommendations are based:

Weighmasters'-Scale Men's Conference.
Minnesota Track and Hopper Scale Department.
National Scale Men's Association.
Grain Dealers Grain Conference Committee.
Elevator Builders and Designers.
Scale and Balance Manufacturers Association.

The Bureau of Standards, Department of Commerce, participated in this work in an advisory capacity.

II. SCALE DESIGN

1. GENERAL.—Scale mechanism, platform, and framing shall be of such design as will insure proper distribution of the weight among the parts when the load is applied, and shall be of such rigidity as will prevent displacement of the bearings on knife-edges, due to deflection of any member or to oscillation of platform or hopper.

2. LOAD DISTRIBUTION.—Scales should be designed to sustain on each corner 25 per cent of the nominal capacity of the scale plus 25 per cent of the dead load of the hopper and frame, etc., without developing in the parts stresses in excess of the proper working stresses.

3. UNIT STRESSES, STRUCTURAL STEEL, IRON AND STEEL CASTINGS.—Levers, loops, links, bearings, and other parts of scales shall be of such section that under the loading or weight determined from the capacity the following unit stresses should not be exceeded.

TABLE 1.—*Working stresses, iron and steel, in pounds per square inch*

Nature of stress	Gray iron castings	Steel castings	Machinery steel	Structural steel [1]	Steel for pivots and bearings
Tension	1,500	8,000	8,000	10,000	24,000
Compression	8,000	10,000	8,000	10,000	24,000
Transverse bending:					
Tension	2,500	8,000	8,000	10,000	24,000
Compression	8,000	10,000	8,000	10,000	24,000
Shear	2,500	6,000	5,000	7,000	----------
Torsion	2,500	6,000	----------	7,000	----------

[1] See also Sections II–6, and XI–3.

4. STEEL PINS.—The bearing stress per square inch on steel pins shall not exceed 15,000 pounds.

5. CONCRETE.—Concrete shall not be required to support more than 400 pounds per square inch.

6. Structural Steel.—Structural steel used in connection with scale or installation shall conform to the specifications for steel structures as adopted by the American Railway Engineering Association, except as provided in the values for working stresses, given herein. (See also sections II–3, and XI–3.)

7. Timber.—Timber used in connection with the installation of scales shall be of the best quality and thoroughly seasoned. In scales of 60,000 pounds capacity or more the inside framing and outside framing shall not be of wood.

8. Interchangeability.—Like parts of a scale of given manufacture, type, and capacity shall be interchangeable so far as practicable.

9. Quality of Castings.—The finished castings of the scale shall not be unduly warped, shall be free from blisters, large holes, or other imperfections, and shall be brought to a reasonably smooth finish.

10. Finish of Castings.—The surfaces of castings which bear on wood or masonry shall be smooth and have a true surface to within a tolerance of one thirty-second of an inch, and surfaces of castings which bear on steel members or on each other shall be machined.

11. Means for Alignment.—Means for vertical and horizontal adjustment shall be provided to insure the proper alignment of the lever system.

12. Cleaning Facilities.—The vital parts shall be readily accessible for cleaning, inspection, and adjustment.

13. General Quality of Performance.—Scales shall be of such construction that they will repeat their weight indications within one-half of the prescribed tolerance on ratio.

14. Check-Rod Arrangement.—When check rods are used they shall be adjustable, and except in the case of suspended hopper scales set as high as possible and without initial strain, and horizontal when average load is on the scale.

III. LEVERS

1. Multiplication.—Levers shall be true to their nominal length between end knife-edges within a tolerance of $\frac{1}{100}$ of an inch per foot, but in all cases the levers shall be adjusted to correct multiplication. The multiplication of levers up to the beam shall be 100 to 1, beam 10 to 1, and counterweights 1,000 to 1, except in scales of less than 9,000 pounds capacity.

2. Leveling Lugs.—Solid levers of built-in scales shall be provided with leveling lugs upon which a level can be placed to establish the longitudinal adjustment of levers. They shall be accurately faced in reference to a plane established by the knife edges, and so that when a level is placed thereon the proper position of the lever

when set will be indicated. The leveling lugs shall be 11 inches apart when practicable.

3. Trussed Lever Features.—The parts of truss levers shall be so cast, made, machined, and assembled that the completed levers will not be warped or drawn out of true lines; and will hang plumb when in position.

4. Marking of Trussed Lever Parts.—The truss rod for each given truss lever shall be clearly and permanently marked to indicate the lever of which it is a part; and the proper length of the rod shall be indicated thereon in a clear, permanent manner. The truss post therefor shall likewise be identified in a similar way.

5. Marking of Trussed Levers.—Figures denoting the position of each lever in the assembled scale shall be marked thereon.

6. Safety Loops.—Safety loops or other means shall be provided under levers or hoppers, to prevent damage from breakage.

IV. NOSE IRONS

1. Adjustment Control.—To insure parallelism of pivots, guides shall be provided where nose irons engage the levers. The nose irons shall be designed for movement by a machine screw, composed of material at least as hard as brass which will not corrode, or other mechanical device. Each nose iron shall be clamped in position by at least two binding screws or bolts, or an equivalent locking device. In scales of more than 72,000 pounds capacity machined guides shall be provided on levers at points where nose irons engage them.

2. Set Screws.—Set screws which make indentations in the levers shall not be used, on account of such indentations making it difficult to secure nose irons in exact position when slight adjustments are made.

3. Factory Marks.—The position of each nose iron shall be clearly indicated by a well-defined mark, showing its position on the lever when adjusted at the factory.

V. KNIFE-EDGES, PIVOTS, BEARINGS, AND LOOPS

1. Material.—Pivots and bearings shall be of hardened and tempered steel. Knife-edges shall be sharp and bear throughout the entire length of the parts designed to be in contact. Bearings shall be smooth and at least as hard as knife-edges.

2. Physical Properties.—The requirements for physical properties of the steel used for pivots shall be as follows:

(*a*) *Special alloy steel in the annealed state.*—

Elastic limit	Not over 75,000 pounds per square inch.
Tensile strength	Not over 110,000 pounds per square inch.
Elongation in 2 inches	Not less than 20 per cent.
Reduction in area	Not less than 35 per cent.

(*b*) *Special alloy steel hardened.*—

Elastic limit	Not less than 160,000 pounds per square inch.
Tensile strength	Not less than 200,000 pounds per square inch.
Elongation in 2 inches	Not less than 5 per cent.
Reduction in area	Not less than 25 per cent.
Shore hardness	Not less than 85.

(*c*) *High-carbon steel in the annealed state.*—

Elastic limit	Not over 55,000 pounds per square inch.
Tensile strength	Not over 117,000 pounds per square inch.
Elongation in 2 inches	Not less than 15 per cent.
Reduction in area	Not less than 25 per cent.

(*d*) *High-carbon steel hardened.*—

Elastic limit	Not less than 135,000 pounds per square inch.
Tensile strength	Not less than 180,000 pounds per square inch.
Elongation in 2 inches	Not less than 3 per cent.
Reduction in area	Not less than 12 per cent.
Shore hardness	Not less than 85.

3. Loading of Knife-Edges.—The load per linear inch of knife-edge shall not exceed 6,000 pounds.

4. Pivot Design Formula.—Where practicable, pivots shall be supported their full length by integral parts of the levers. The supports should be of such design as to carry the total load applied to the pivots without exceeding the unit stresses herein provided.

Where impracticable so to support the pivots, the bending moments shall be determined as follows:

Let

W = total load on both ends of pivot, in pounds,
L = lever arm required, in inches,
l = bearing surface in loop, in inches,
T = distance between friction faces of loop,
B = width of boss or sustaining member enveloping pivot, in inches.
M = bending moment in pivot, in inch-pounds,

Then

$$L = l\frac{1}{2} + (T - B) + \frac{1}{4} \text{ inches}$$

And

$$M = \frac{WL}{2} = \frac{W}{2}\left[(l\frac{1}{2} + (T - B) + \frac{1}{4}\right] \text{inches})$$

5. Pivot Shape.—Round-back pivots shall not be used in levers supporting heavy loads, unless of special design to prevent twisting.

6. Pivot Design and Installation.—Knife-edges, pivots, and bearing steels shall be properly fitted and so mounted, reinforced, and

designed in relation to flexure that uniform contact and pressure will be secured under all conditions of loading. All pivots shall be designed and manufactured so that the two sides joining to form the knife-edge shall form an angle that will not exceed 90°; that the tolerance for offset of the knife-edge of pivots, as figured from the center line of the pivot shall be within 10 per cent of the width of the pivot for "machined in" pivots, and 15 per cent of the width of the pivot for "cast in" pivots. Bearings shall be self-aligning wherever practicable. Knife-edges and bearing steels shall be fitted in machined ways when necessary to comply with the requirements of this paragraph. The pivots shall be so mounted that each knife-edge in a given lever will be maintained in a horizontal plane; and so that the knife-edges in a given lever will be parallel to each other.

7. Calking.—Calking around pivots for the purpose of tightening them in the lever shall not be permitted.

8. Antifriction Contacts.—Antifriction contacts shall be used to limit longitudinal displacement between knife-edges or pivots and their bearings. They shall be smooth, at least as hard as the parts with which they come in contact, and so designed as to provide contact at a point on the line of the knife-edge of the pivots.

9. Material for Bearing Steels.—The character of the material for bearing steels will be found under "Steel for Pivots" (paragraph 2 above). The bearing steels shall be equal to or greater in hardness than the knife-edges which oppose them. It is found good practice to have the bearing steels not less than 95 points hardness on the Shore recording scleroscope for high carbon steel, and not less than 90 for special alloy steel.

10. Design of Bearings.—Scales shall be so designed that the oscillation of the platform will not displace the bearings at points of contact on the knife-edges.

11. Finish of Bearing Steels.—The bearing surfaces shall be brought to a smooth, true, and accurate finish to provide continuity of contact with the opposing knife-edges. Self-aligning bearings shall be used wherever practicable.

12. Platform Bearings.—The tops of platform bearings making contact with the girders shall be true to within one thirty-second of an inch of a true plane that will bring them all to the same height when in position, and in a plane parallel to the bottom of the bases of the fulcrum stands. They shall be as short as is practicable. These tops shall be provided with bolt holes of a sufficiently large diameter to allow for adjustment both transversely and longitudinally to secure alignment of parts.

13. Loops.—To reduce friction between the loops and levers, the friction faces of all loops shall be flat, instead of pointed, and the

levers equipped with one point hardened contact in line with the knife-edge of the pivot.

14. Loop Design.—The loops may be of any type desired, provided the radius of the portion of the bearing making immediate contact with the knife-edge, and the radius of the eye of the loop shall not be less than the length of the longest side of the cross section of the pivot to be used in the loop.

15. Loop Design Formula.—In the design of loops the unit stresses shall not exceed those specified in the table for working or design stresses provided herein; and considering the end of the loop as a simple beam, its section at the point of maximum bending moment should be determined by the formula $W/4(L-l/2)$:

Wherein

W = The maximum load to be provided for on the link or loop,

L = The distance between center lines of depending sides,

and

l = The distance over which the load is distributed.

VI. LEVER FULCRUM STANDS

1. Height of Pillars and Area of Bases.—The height of the pillars and the dimensions of the bases of the stands shall be such as to prevent a tipping action. In stands of the two-pillar type, both pillars shall be of equal height.

2. Pillars, Positions on Bases.—The pillars or upright portions of the stands carrying the bearings shall be so placed on the bases that the centers of the bearing lines shall be over the centers of gravity of the bearing surface of the stands.

3. Anchor Bolt Holes.—Two or more anchor bolt holes, not less than 2 inches in diameter, shall be provided in proper places in the bases of all the stands, unless other equally effective means for anchorage is provided.

VII. BEAM FULCRUM STAND

1. Design.—The beam shall be supported on a stand provided with compensating bearings and shall not be suspended. The height of the pillars and the dimensions of the base of the stand shall be such as to prevent a tipping action.

2. Height.—The height of the stand, measured from the bottom surface of the base to the pivot bearing surface, shall not exceed 20 inches.

3. Finish.—The bearing surface of the base of the stand shall be finished to a plane perpendicular to the axis of the upright portion of the stand, and the knife-edge line of the bearing shall be parallel to the base. The center of the bearing line shall be vertically over the center of gravity of the bearing surface of the base.

VIII. WEIGHBEAM, ATTACHMENTS, AND ACCESSORIES

1. Beam Rod and Steelyard Rod.—The steelyard rod shall be adjustable as to length by: (*a*) Turnbuckles secured by lock nuts at threaded ends; or (*b*) by specially designed turnbuckles which effectively prevent the accidental change of the length of the steelyard rod.

2. Beams and Poises.—The maximum value of minimum divisions on beam shall be as follows:

On scales of 2,000, 3,600, and 6,000 pounds capacity, smallest graduation, 1 pound.

On scales of 9,000 pounds capacity, smallest graduation, 2 pounds.

On scales of 12,000, 18,000, 24,000, 30,000, 36,000, and 48,000 pounds capacity, smallest graduation, 5 pounds.

On scales of 60,000 pounds capacity and over, smallest graduation, 10 pounds.

3. Graduations.—Weighing beam shall be so marked and graduated, and poises so constructed, that the weights corresponding to any position of the poise may be clearly read without moving the poise, whether or not a recording device is used.

4. Full-Capacity Beams.—Compound beams, or beams of the full-capacity type, shall not be used except where the notches do not represent a greater value than 200 pounds per inch, and in all such cases where notches are used, they shall face outward or downward on the beam, in order to prevent the accumulation of dust or dirt.

5. Type Hardness.—Where type registering beams are used, the figures shall be of a material at least as hard as bronze.

6. Zero Stops.—A shoulder stop shall be provided on beam to prevent poise traveling back of the zero graduation.

7. Capacity Marking.—The capacity of the scale shall be clearly and permanently indicated on the scale beam in such a place as to be readily visible from the operator's position.

8. Level Indicator.—The normal position of the beam shall be horizontal, and it shall have equal travel in the trig loop above and below the horizontal position. Beams shall be fitted with a pointer to be used in connection with a fixed indicator which will show a central position in the trig loop when the beam is horizontal.

9. Height of Beam.—The maximum height of the pivot line on the weigh beam shall not exceed 5 feet 6 inches above the floor line.

10. Trig-Loop Travel.—The minimum travel of beam in trig loop shall conform to the following for the various lengths of beams:

Length of beam, fulcrum pivot to trig loop:	Minimum travel, inch.
Under 12 inches	0.4
Over 12 inches, including 20 inches	.5
Over 20 inches, including 40 inches	.7
Over 40 inches	.9

11. Balance Ball.—A balance ball shall be provided and its movement shall be controlled by means of a hand-operated screw or other device which will not require that the ball be rotated in making any adjustments. The balance ball shall be provided with means for vertical adjustment.

12. Poises, Unit Construction.—Poises shall be so constructed that no part can be easily detached, and when equipped with set screws or other clamping devices, these shall be retained in such a way that they will not work out or become detached.

13. Adjusting Cavity.—The adjusting material in poises shall be securely inclosed in a single cavity and firmly fixed in position, and if softer than brass, shall not be in contact with the beam.

14. Sensibility Reciprocal.—The sensibility reciprocal is the weight required to move the beam a definite amount from pointer or other indicating device of a scale. In a scale provided with a trig loop, the sensibility reciprocal is the added weight required to be placed upon the platform to break and turn the beam from a horizontal position in the middle of the loop to a position of equilibrium in the top of the loop. This may be determined by subtracting the weight, instead of adding it, or by using the sliding poise on the beam, if this be done without jarring the beam. The sensibility reciprocal shall never exceed the amount given in the following table:

Table 2.—*Maximum allowable values of the sensibility reciprocal of grain scales*

Capacity in pounds	Sensibility reciprocal	Capacity in pounds	Sensibility reciprocal
	Pounds		*Pounds*
3,000	1	48,000	8
9,000	2	60,000	10
12,000	3	72,000	12
18,000	4	84,000	13
24,000	5	96,000	14
30,000	6	120,000 and up	15

15. Weights.—Counterpoise weights shall be made of steel, iron, brass, or any other metal or alloy of metals not softer than brass. They shall have plain or smooth surfaces and no sharp points or corners. Surfaces shall be machined with suitable radius on outside edges to avoid chipping.

16. Coating of Weights.—Counterpoise weights of iron or steel shall be given a protective coating, and preferably shall be nickel-plated.

17. Adjusting Material.—The adjusting material in weights of 2-pound value or more shall be securely inclosed in a single cavity in the top or sides of the weights, and firmly fixed in position, and shall not project beyond the surface of the weights.

18. Marking of Weights.—Counterpoise weights shall be clearly marked with their actual values, and also with the values that they represent when used on the scale for which they are intended. Where the surfaces of the weights are machined and finished, the figures and letters representing these values shall be stamped in the metal and not cast or forged in relief.

19. Required Accuracy of Weight Adjustment.—The tolerances to be allowed in excess or deficiency on commercial counterpoise weights shall be the values shown in the table below: Provided, however, that the manufacturers' tolerances or the tolerances to be allowed on new commercial counterpoise weights shall be one-half of the values given.

Table 3.—*Tolerances for counterpoise weights*

Weight	Tolerance, counterpoise weights for multiplying lever scales		
	Ratio less than 100:1	Ratio 100:1 and less than 1,000:1	Ratio 1,000:1 and over
Pounds:	*Grains*	*Grains*	*Grains*
10	24.0	16.0	8.0
8	18.0	12.0	6.0
5	18.0	12.0	6.0
4	12.0	8.0	4.0
3	12.0	8.0	4.0
2	9.0	6.0	3.0
1	6.0	4.0	2.0
Ounces:			
10	6.0	4.0	2.0
8	3.0	2.0	1.0
5	3.0	2.0	1.0
4	3.0	2.0	1.0

20. Weight Racks.—Weight racks, where they come in contact with, or support, the counterpoise weights, shall be provided with a soft material, such as rawhide, fiber, wood, etc., to reduce the wear on the weights to a minimum.

21. Counterpoise Hanger.—The cup or holder on the base of the counterpoise stem shall be securely fastened to the stem in a manner to insure against a slipping or dropping thereof.

22. Loose Counterpoise Material.—Loose material used in counterpoise cups for adjusting the balance of beam shall be securely inclosed.

23. Counterbalance Weights.—If counterbalance weights are to be used, the lower end of the hanger stem shall be threaded; a cup for loose balancing material shall be screwed to the lower end of the stem and each additional weight shall be provided with an elongated hole in the center through which the hanger stem may pass. No slotted counterbalance weights are to be used. When no counterbalance weights are necessary on top of the counterbalance cup

the cavity shall be closed by a cover secured in a positive manner. No counterbalance weights shall be used in any place in the scale, except at the beam.

IX. CLEARANCES

1. General.—The minimum clearance between fixed and movable parts of the scale shall not be less than one-half inch except on dormant hopper scales where the clearance shall not be less than three-sixteenths of an inch.

2. Antifriction Attachments.—The clearances between the antifriction plates and antifriction points shall not exceed one-sixteenth of an inch on the beam, one-eighth of an inch on the shelf lever, and one-fourth of an inch on all other levers, and the minimum clearances shall be not less than one-half these amounts, respectively.

X. HOPPER

1. Hopper Design and Construction.—The bushel capacity of hopper shall govern the size of platform or structure supporting the hopper, also the length of scale levers. The hopper shall not extend beyond the frame of the scale to such an extent nor be of such height as may result in a tipping action of the platform. The hopper may be constructed of either wood or steel, preferably the latter. It shall be substantially constructed, grain tight; be braced and stayed to prevent bulging; be smooth on the inside and free from all obstructions.

2. Hopper Capacity.—The capacity of the hopper shall not exceed 20 cubic feet per 1,000 pounds, or 1.2 cubic feet per bushel of the indicated capacity of the scale.

3. Valleys.—The bottom shall be so formed or the valleys so filled that sharp V valleys will be avoided. In all cases of wood construction the valleys in the hopper shall be covered with metal. The pitch of the valleys shall be not less than 36°. All fastenings extending into the interior shall be countersunk flush with the inside.

XI. FOUNDATION

1. Support.—The supporting structure for hopper scales shall be rigid and extend up from the main foundation of the elevator. The immediate supports of hopper scale shall be the scale floor, constructed preferably of reinforced concrete. Floor openings under scale and hopper shall not be greater in number and size than required for reasonable clearance around discharge outlet and test weight supports.

2. Masonry.—The masonry on which scale or scale supports rest should be constructed of concrete, vitrified brick, or cut stone.

When either of the latter two materials is used, they shall be laid in cement mortar. Foundations shall be constructed in accordance with the best engineering practice. When scales are supported directly by masonry foundations, the bearing surfaces shall be true.

3. Structural Steel.—Structural steel members supporting scales, or to which scale parts are connected, shall not be stressed beyond 16,000 pounds per square inch. Other materials shall have an equivalent factor of safety. See Sections II, 3, and II, 6.

4. Beam Location.—The beam shelf or stand shall be supported by the structure which immediately supports the scale and hopper.

XII. INSTALLATION

1. Drawings.—On request, the manufacturer shall furnish to the purchaser plans of design showing stresses and detailed dimensions for all scale parts and the material of which they are to be fabricated also assembly plans showing location of all field connections and all information necessary for the purchaser to erect the scale.

2. Use of Drawings.—The purchaser shall furnish to the supervising agency, on request, the foregoing plans, together with his plans for the construction and location of all receiving pits, boots, boot pans, elevating legs, heads of same, garners, hoppers, spouting, shipping bins and accessories and appurtenances thereto, essential to the receiving and shipping of commodities through the scales to be installed, including the foundations thereof.

3. Location.—Scales must be so located that they will not be affected by vibration or strong air currents, and there shall be no obstruction that will interfere with the testing or weighing. No scales shall be installed in a bin, over an open bin or open pit.

Scales supported or suspended from four corners shall not rest on bin cribbing. The scale shall be so located that its load will be approximately equally distributed on the supporting members of the building.

4. Hopper Clearances.—Hopper scales must be so located that no part of the hopper will be nearer than 6 inches to any part of the building, nor an adjacent hopper, and in every case all parts of the scale shall be accessible for inspection and maintenance.

5. Hopper Support.—The scale hopper shall be supported vertically over the centers of the lever load knife-edges. The design of the scale and structure shall be such that the bearings will not be displaced at points of contact with the knife-edges when load is applied.

6. Bearing Feet Attachment.—The bearing feet shall be securely bolted to the platform in proper positions without the use of clips or other outside fastenings, and shall be plumbed and aligned, to insure the coincidence of the center lines of the platform bearings

with the center lines of the levers, and so that the load pivot knife-edges will make contact on the center lines of the bearing steels.

7. Corner Fulcrum Stands.—The corner fulcrum stands shall be set level and plumb, without shims, and securely anchored in proper alignment and position.

8. Fulcrum Eyebolts.—The corner fulcrum eyebolts shall pass through the approximate centers of their supporting plates or stands. They are to be straight, plumb, and properly spaced and aligned for the levers which they support. Bearing surfaces of corner plates or stands, and nuts on eyebolts shall be true and at right angles to the axes of the bolts.

9. Extension Levers.—No extra or extension levers shall be used to connect to the weigh beam; providing, however, when necessary, a shelf lever or equivalent may be arranged for this purpose. The connections from the main levers to the shelf lever, or equivalent, and to the beam shall be of such design that the twisting effect will be avoided, and so that the load will be distributed properly on the knife-edges. The shelf lever, or equivalent, shall be carried on a support which will not yield under maximum load. Twisted one-piece connections shall not be used.

10. Accessibility of Parts.—Where scale levers are located beneath the floor, a permanent runway or gallery shall be provided wherever possible, to permit full accessibility for inspection, cleaning, or adjusting.

11. Paint.—All metal parts of scales, including structural steel, shall have not less than two coats of paint before installation, and shall be cleaned and painted at such other times as may be necessary.

12. Garner Capacity.—The garner shall be of as great a capacity as is practicable, preferably larger than maximum carload capacity; shall be substantially constructed, grain tight; shall be braced and stayed to prevent bulging; and shall be smooth on the inside and free from all obstructions.

13. Garner Valleys.—The bottom shall be so formed, or the valleys filled so that sharp V valleys will be avoided. In all cases of wood construction the valleys in garners shall be lined with metal. The pitch of the valleys shall be not less than 40°. All fastenings, extending into the interior, shall be countersunk flush with the inside.

14. Garner Outlets.—The outlets or discharges from the garners shall be not less than 10 inches in their shortest dimensions and shall be substantially made of steel or iron, and so constructed that they will not leak. They shall be located so as to accomplish an even distribution of the load in the scale hopper. The valves shall operate freely.

15. Garner and Hopper Slides.—The devices for operating the scale hopper and garner slides shall be located on the beam side

of the hopper, within convenient reach, but shall not interfere with the action or accuracy of the scale. They shall be equipped with means to indicate the closed position of the slides, and to prevent accidental opening thereof. All hopper valve levers shall be moved in the same direction to perform similar functions.

16. Canvas Covers.—When canvas is used inside to close opening between garner and hopper, it shall be attached to and suspended from the garner only and provision made for the free escape of air.

17. Pipes and Signal Lines.—Vent pipes extending through the roof of the elevator shall not be placed in scale hoppers. No pipes, signal wires, or other obstructions of a similar nature shall pass through a scale hopper or be attached thereto or to the scale parts.

XIII. TESTING

1. Test Weights, Primary.—The standard of mass for testing grain scales shall be derived from primary weights, verified by the United States Bureau of Standards, Washington, D. C., to within what is known as their "class B" tolerance, as is given in the following table:

Table 4.—*Tolerances for primary test weights (class B)*

Weights, avoirdupois in pounds	Tolerance, class B	Weights, avoirdupois in ounces	Tolerance, Class B
	Grains		*Grain*
50	2.0	10	0.2
25	1.2	8	.1
20	1.2	5	.1
15	.8	4	.1
10	.8	2	.06
8	.6	1	.04
5	.6	½	.04
4	.4	¼	.02
3	.4	⅛	.01
2	.3	1/16	.01
1	.2	1/32	.01
		1/64	.004

2. Test Weights, Secondary.—The 50-pound secondary or working cast-iron weights used directly in testing scales should be rectangular, and of such design as to facilitate stacking; they shall be free from pockets, blowholes, etc., which are liable to catch and hold foreign matter. No adjusting cavity or cavities in the bottoms of such weights shall be permitted.

These weights shall be tested and adjusted in comparison with the master weight, which has been verified to within "class B" tolerance. The working weights shall be adjusted to within 20 grains and maintained to within 50 grains of their true value.

Standard counterpoise weights shall be used for testing leverage ratio and value of poises.

3. Method of Test.—All scales shall be tested with standard test weights to at least 8 per cent of their maximum capacity, and these weights are to be used in multiples of 1,000 pounds. New, repaired, or rebuilt scales shall be tested prior to being put in service. For individual corner tests, at least one-quarter of the respective test loads specified shall be used. The sensibility reciprocal shall be determined, and the sliding poise and counterpoise weights tested by comparison with the standard counterpoise weights applied at the end of the beam.

In conjunction with the above test, a load test shall be made to determine if any interference occurs between the fixed and movable parts of the scale, and to discover any weakness due to yielding in supporting structure, etc., by filling scale hopper with grain to its usual working or maximum capacity, less the amount of test weights used. The beam shall be balanced, after which sufficient time shall elapse to determine any leakage through gate valves; if none occurs, the test weights can be applied to prove the correctness of the scale under load. The sensibility reciprocal shall again be obtained under this maximum load for comparison with that shown under test with test weights alone, or when the scale is not loaded.

The location of the scale shall be such that adequate means can be provided to permit of the suspension of standard test weights at each corner, so that the center of gravity of the test load will be on a vertical line that passes through the center of the main bearings.

All scales shall be tested when loaded to their working capacity.

4. Frequency of Test.—Scales in regular service shall be tested at least once each year, and every six months where practicable.

5. Accuracy Requirements.—Scales will be considered commercially accurate when any error, developed by the test through applying calibrated standard test weights uniformly distributed, does not exceed one-half pound per 1,000 pounds of the load of standardized test weights used, said test load being applied to the scale with the scale hopper empty, approximately one-half loaded, and approximately loaded to capacity: Provided, however, that when test weights are applied to the corners, the allowable error for any corner shall not exceed twice the foregoing tolerance applied on that corner.

The error observed at any step may be plus or minus.

For new scales and wherever adjustments or repairs are made or wherever in the judgment of the inspector the errors indicated by the scale are excessive, the corner tests shall be carried out at zero and full load.

APPENDIX

Amendments to Specifications for Hand-Operated Grain Hopper Scales, Proposed for Consideration by the Scale and Balance Manufacturers Association

Subsequent to the formal preparation and promulgation of the foregoing specifications, developments in the trade and detailed scrutiny of practical requirements led to certain amendments to the specifications being proposed for consideration. A comprehensive list of these is embodied in a letter from the secretary of the Scale and Balance Manufacturers Association under date of October 15, 1924. This list of suggestions is published verbatim here in order to bring them generally before the various parties in interest and to invite formal expressions of opinion regarding them. Such as are found to meet practical demands with general satisfaction will doubtless eventually be incorporated in the specifications.

THE SCALE AND BALANCE MANUFACTURERS ASSOCIATION,
17 STATE STREET,
New York, October 15, 1924.

BUREAU OF STANDARDS,
Department of Commerce,
Washington, D. C.

Subject: Grain-Hopper Scale Specifications

GENTLEMEN: The hopper scale specifications, as drafted by you for publication and which you referred to us under date of August 9 last, were given due consideration at a recent meeting of our association. The conclusions reached by the manufacturers lead them to suggest the following amendments. These changes would, we believe, bring the specifications more into line with customary practice while in no material way affecting the essential or important features of the specifications.

1. Section III. Paragraph 6.—*Safety Loops.*

Safety loops are unnecessary and impractical of application when scales are supported from floor stands and the opening in the floor is only sufficient to clear the discharge valve on the hopper.

We recommend that an exception be incorporated into the specifications to cover this condition which appears to be the approved construction in modern terminal elevators.

2. Section VIII. Paragraph 2.—*Beams and Poises.*

Specifications call for 10-pound minimum graduations on the beams for scales of 60,000 pounds and over. General manufacturing practice (based on the demands of the grain trade) is to use 5-pound graduations. We suggest that the specifications be changed accordingly.

3. Section VIII. Paragraph 4.—*Full-Capacity Beams.*

Specifications limit the value of the notches for full-capacity beams to 200 pounds per inch. We suggest that the use of full-capacity beams be limited by the test of their sensibility and accuracy rather than by structural limitations. The multiplication at the butt of the beam should not be limited to 100. It is believed that the elevator men would generally prefer to use a full-capacity beam, if one might be contrived to maintain its accuracy and reliability of service under the usual trying conditions of grain hopper weighing; but the limitation

of 200 pounds per inch would unquestionably act as a discouragement to invention and progress along these lines.

4. Section VIII. Paragraph 11.—*Balance Ball.*

Vertical adjustment is specified for the balance ball. This paragraph should be modified so as to permit the use of two balance balls—one for horizontal, the other for vertical adjustment. It was suggested that possibly the substitution of "A" for "The" at the beginning of the last sentence, making it read "A balance ball shall be provided with means for vertical adjustment," might serve to cover this point.

5. Section VIII. Paragraph 20.—*Weight Racks.*

Soft material, such as rawhide, wood, etc., is specified for weight racks. We suggest that some soft metal, such as brass, be included in the designation of soft material.

Trusting these suggestions will meet with your approval, we remain,

Yours very truly,

(Signed) OTIS L. WILLIAMS,
Secretary-Treasurer.

WASHINGTON, September 19, 1924.