This Excel workbook includes 12 sheets. Use arrows at left of sheet tabs to view all sheets.

Lowest Reading Instructions | Lowest Reading Calculator | Steep Grade Instructions | Steep Grade Calculator

D&RGW RR Legend Plate | UP RR "Big Boy" | GC&E RY 150 Ton Shay | SP RR AC-12 Cab Forward

SP&S RY E-1 No. 700 |BLW SPS 12-1B and 12-1C Excerpts | BLW SPS 12-4A Excerpts | BLW SPS 12-1D

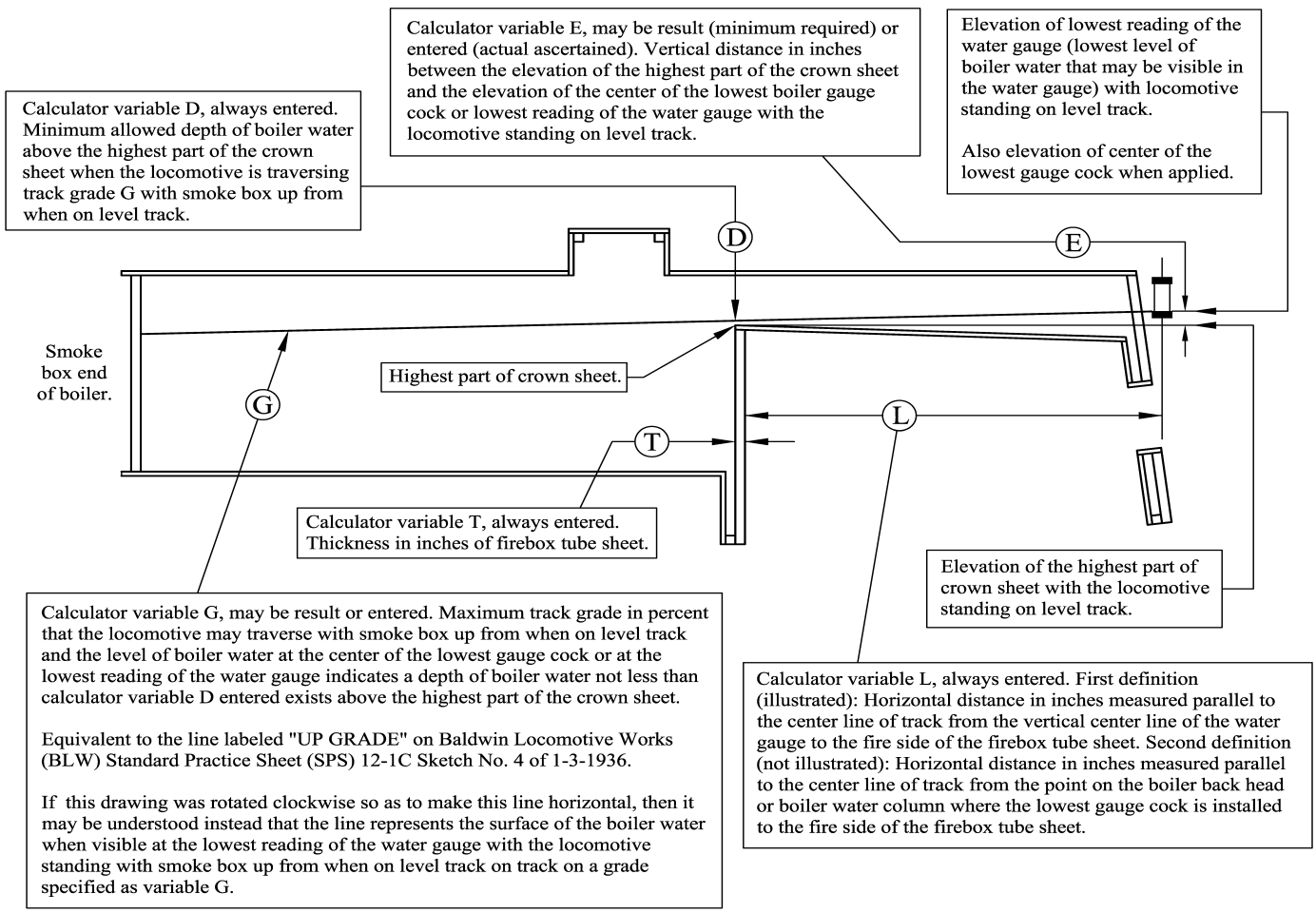
Excel Workbook Produced by Jeffrey G. Hook Revision of September 1, 2025

See notice below drawing.

Instructions for Excel Calculator that Establishes the Elevation of the Lowest Reading of a Water Gauge or Center of the Lowest Gauge Cock Applied on a Steam Locomotive Boiler using Baldwin Locomotive Works Standard Practice Sheet 12-1C Sketch No. 4 Principles

Deerfield and Roundabout Railway
Lake Forest Live Steamers Railway Museum
Produced by J. G. Hook

Formulas: E = (L + T) * (G / 100) + D therefore G = (E - D) / (L + T) * 100



Excel Calculator that Establishes the Elevation of the Lowest Reading of a Water Gauge or Center of the Lowest Gauge Cock Applied on a Steam Locomotive Boiler using Baldwin Locomotive Works Standard Practice Sheet 12-1C Sketch No. 4 Principles

Note No. 1: Measurements shall be ascertained only when locomotive is standing on level track and locomotive weight and spring rigging is in normal working order.

Enter values for variables L , T and D in all cases.

Variable	Full Scale Practice Applicable to BLW SPS 12-1C Sketch No. 4	1:8 Scale Miniature Practice Applicable to 7.5 Inch Nominal Gauge of Track DRRY
L Entered 0.000	Horizontal distance in inches measured parallel to the center line of track from the point on the boiler back head or boiler water column where the lowest gauge cock is installed to the fire side of the firebox tube sheet.	Horizontal distance in inches measured parallel to the center line of track from the vertical center line of the water gauge to the fire side of the firebox tube sheet.
T Entered 0.000	Thickness in inches of firebox tube sheet.	Same.
D Entered 0.000	Depth of boiler water above the highest part of the crown sheet when the locomotive is traversing track grade G with smoke box up from when on level track shall be not less than 1.0 inches.	Same except shall be not less than 0.250 inches instead.

IN 1:8 SCALE MINIATURE PRACTICE VARIABLE D MUST NOT BE ENTERED AS LESS THAN 0.250 INCHES

To find resulting value for variable E enter value for variable G.

G Entered 0.00	Maximum track grade in percent that the locomotive is intended to traverse with smoke box up from when on level track and the level of boiler water at the center of the lowest gauge cock indicates a depth of boiler water not less than D exists above the highest part of the crown sheet. The value G to be specified by the railroad company requesting construction of the locomotive subject to being less than 7.0 percent.	Maximum track grade in percent that the locomotive is intended to traverse with smoke box up from when on level track and the level of boiler water visible at the lowest reading of a water gauge indicates a depth of boiler water not less than D exists above the highest part of the crown sheet. Taken as 2.5 percent or that as specified by current rules and regulations of the DRRY or LFLSRM.
$E_{MINIMUM}$ Result	Minimum required vertical distance in inches between the elevation of the highest part of the crown sheet and the elevation of the center of the lowest boiler gauge cock. If the result for E is less than 3.5 inches then 3.5 inches shall be used instead. (See Paragraph 3 on BLW SPS 12-1B and Note No. 1 on BLW SPS 12-4A)	Minimum required vertical distance in inches between the elevation of the highest part of the crown sheet and the elevation of the lowest reading of a water gauge. If the result for E is less than 0.500 inches then 0.500 inches shall be used instead.

To find resulting value for variable G enter value for variable E.

E_{ACTUAL} Entered 0.000	Actual vertical distance ascertained in inches between the elevation of the highest part of the crown sheet and the elevation of the center of the lowest boiler gauge cock. See Note No. 1 above.	Actual vertical distance ascertained in inches between the elevation of the highest part of the crown sheet and the elevation of the lowest reading of a water gauge. See Note No. 1 above.
G Result	Maximum track grade in percent that the locomotive shall be allowed to traverse with smoke box up from when on level track and the level of boiler water at the center of the lowest gauge cock indicates a depth of boiler water not less than D exists above the highest part of the crown sheet.	Maximum track grade in percent that the locomotive shall be allowed to traverse with smoke box up from when on level track and the level of boiler water visible at the lowest reading of a water gauge indicates a depth of boiler water not less than D exists above the highest part of the crown sheet.
Notes	A series of four Baldwin Locomotive Works Standard Practice Sheets related to the locating of gauge cocks and water gauges on steam locomotive boilers of their former production are presented in their entirety in the Lake Forest Live Steamers Railway Museum / Deerfield and Roundabout Railway document titled Fundamentals of Steam Locomotive Boiler Water Level Management.	If installed, the center of the lowest gauge cock applied to the boiler back head or water column shall be at the same elevation as that determined for the lowest reading of a water gauge.

Excel Workbook Produced by Jeffrey G. Hook Revision of September 1, 2025

Instructions for Excel Calculator that Establishes the Minimum Height of Boiler Water That MUST be Visible Above the Lowest Reading of a Water Gauge to Allow a Steam Locomotive to Traverse a Steep Track Grade using Baldwin Locomotive Works Standard Practice Sheet 12-1D Paragraph 8 Principles

Deerfield and Roundabout Railway
Lake Forest Live Steamers Railway Museum

Produced by J. G. Hook

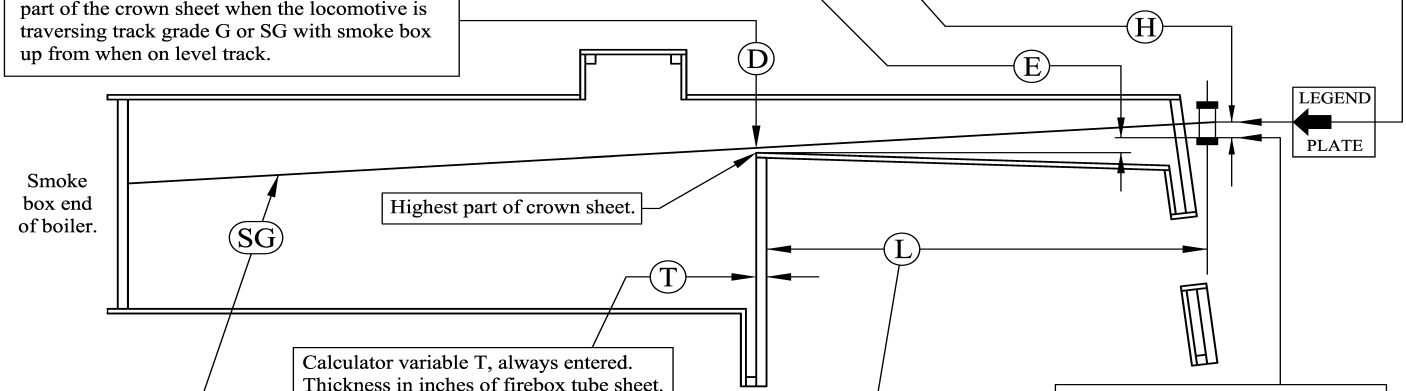
Formula: H = (L + T) * (SG / 100) + D - E

Calculator variable E, always entered (actual ascertained). Actual vertical distance ascertained in inches between the elevation of the highest part of the crown sheet and the elevation of the lowest reading of the water gauge with the locomotive standing on level track.

Calculator variable H, result only. Minimum vertical distance in inches between the lowest reading of the water gauge and the surface of the boiler water visible in the water gauge when traversing grade SG with smoke box up from when on level track.

Legend plate securely mounted in close proximity to the water gauge with explanation of grade SG and horizontal arrow pointing to the minimum level of boiler water that must be visible in the water gauge when traversing grade SG with smoke box up from when on level track. Based on BLW SPS 12-1D Paragraph 8 principles.

Calculator variable D, always entered. Minimum allowed depth of boiler water above the highest part of the crown sheet when the locomotive is traversing track grade G or SG with smoke box up from when on level track.



Calculator variable T, always entered. Thickness in inches of firebox tube sheet.

Lowest reading of the water gauge (lowest level of boiler water that may be visible in the water gauge).

Calculator variable SG, always entered. Maximum steep track grade in percent that the locomotive may traverse with smoke box up from when on level track and the level of boiler water visible in the water gauge at or above the arrow on the legend plate mounted in close proximity to the water gauge indicates a depth of boiler water not less than calculator variable D entered exists above the highest part of the crown sheet.

Calculator variable L, always entered. First definition (illustrated): Horizontal distance in inches measured parallel to the center line of track from the vertical center line of the water gauge to the fire side of the firebox tube sheet. Second definition (not illustrated): Horizontal distance in inches measured parallel to the center line of track from the point on the boiler back head or boiler water column where the lowest gauge cock is installed to the fire side of the firebox tube sheet.

Excel Calculator that Establishes the Minimum Height of Boiler Water That MUST be Visible Above the Lowest Reading of a Water Gauge to Allow a Steam Locomotive to Traverse a Steep Track Grade using Baldwin Locomotive Works Standard Practice Sheet 12-1D Paragraph 8 Principles

Note No. 1: Measurements shall be ascertained only when locomotive is standing on level track and locomotive weight and spring rigging is in normal working order.

Values for variables L, T, D and E ACTUAL automatically entered from "Lowest Reading Calc" sheet.

Variable		1:8 Scale Miniature Practice Applicable to 7.5 Inch Nominal Gauge of Track DRRY
L Entered 0.000		Horizontal distance in inches measured parallel to the center line of track from the vertical center line of the water gauge to the fire side of the firebox tube sheet.
T Entered 0.000		Thickness in inches of firebox tube sheet.
D Entered 0.000		Depth of boiler water above the highest part of the crown sheet when the locomotive is traversing track grade SG with smoke box up from when on level track shall be not less than 0.25 inches.
IN 1:8 SCALE MINIATURE PRACTICE VARIABLE D MUST NOT BE ENTERED AS LESS THAN 0.250 INCHES		
E ACTUAL Entered 0.000		Actual vertical distance ascertained in inches between the elevation of the highest part of the crown sheet and the elevation of the lowest reading of the water gauge. See Note No. 1 above.
To find resulting value for variable H enter value for variable SG.		
SG Entered 0.00		Maximum steep track grade in percent that the locomotive is intended to traverse with smoke box up from when on level track and the level of boiler water visible at the value H vertical distance above the lowest reading of the water gauge indicates a depth of boiler water not less than D exists above the highest part of the crown sheet.
H Result		Minimum vertical distance in inches between the lowest reading of a water gauge and the surface of the boiler water visible in the water gauge when traversing track grade SG with smoke box up from when on level track.

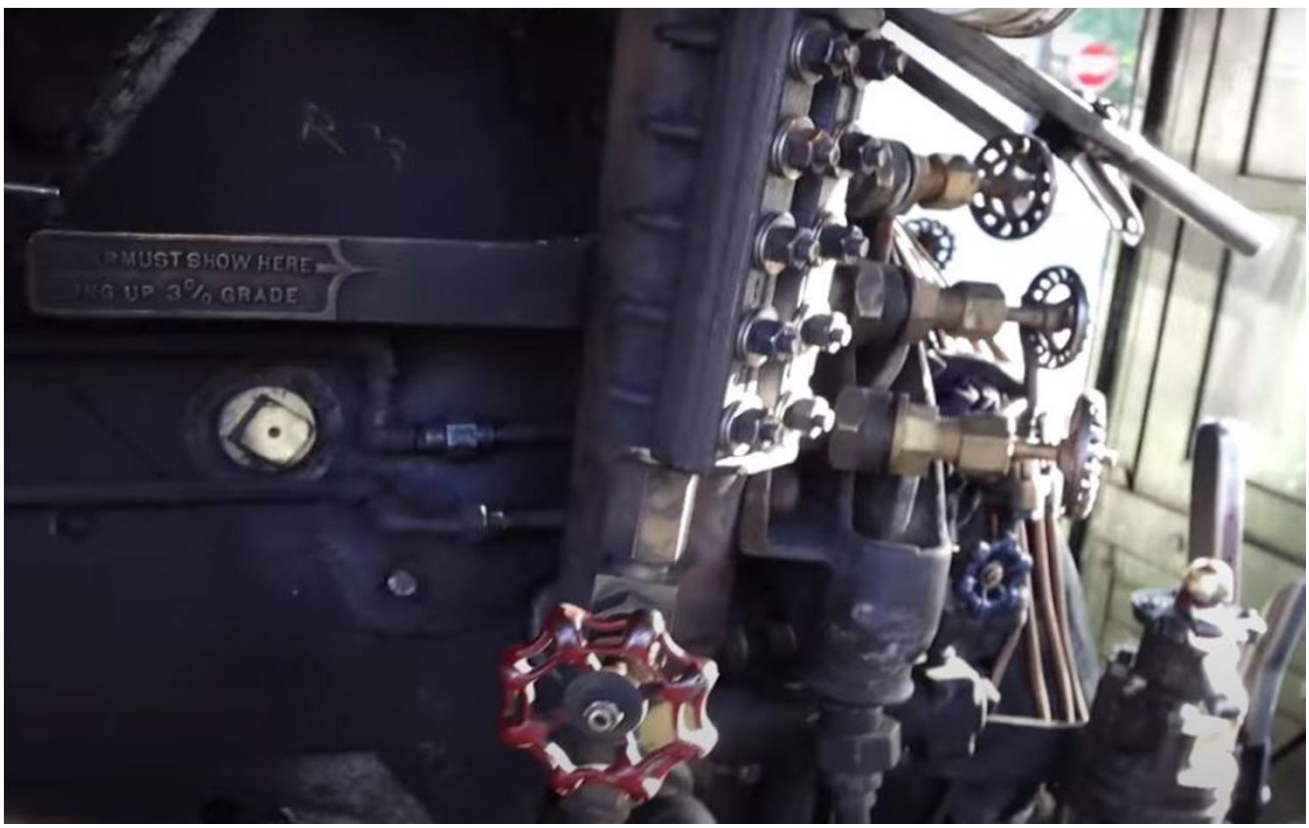
Excel Workbook Produced by Jeffrey G. Hook Revision of September 1, 2025

FORMER DENVER AND RIO GRAND WESTERN RAILROAD ENGINE No. 473 IN SERVICE ON DURANGO AND SILVERTON RAILROAD CIRCA 2020

Image of boiler back head illustrating legend plate securely mounted in close proximity to the water gauge.

Legend plate with horizontal arrow and reading "WATER MUST SHOW HERE GOING UP 3% GRADE."

Image recorded by B. M. Caughron.



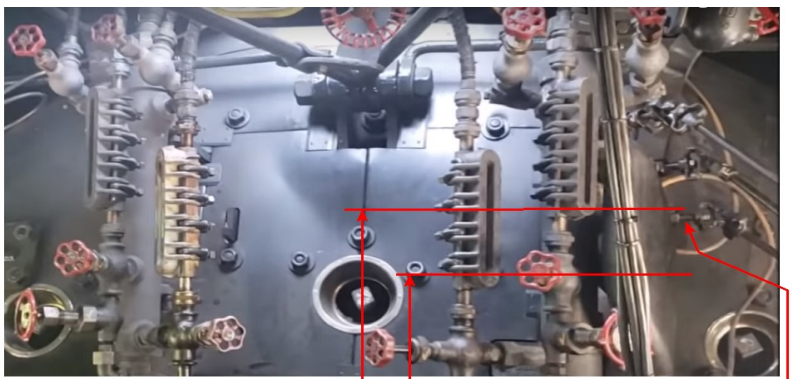
Excel Workbook Produced by Jeffrey G. Hook Revision of September 1, 2025

Image of boiler back head illustrating application of overlapped tandem water gauges (water glasses) in order to provide for extended reading of level of boiler water. Lowest gauge cock (bottom gauge cock) located at the same elevation as the lowest reading of the upper water gauges instead of located at the same elevation of the lowest reading of the lower water gauges.

Approximate horizontal distance measured parallel to the center line of track from vertical center line of water column to combustion chamber tube sheet 343 inches. See drawing below.

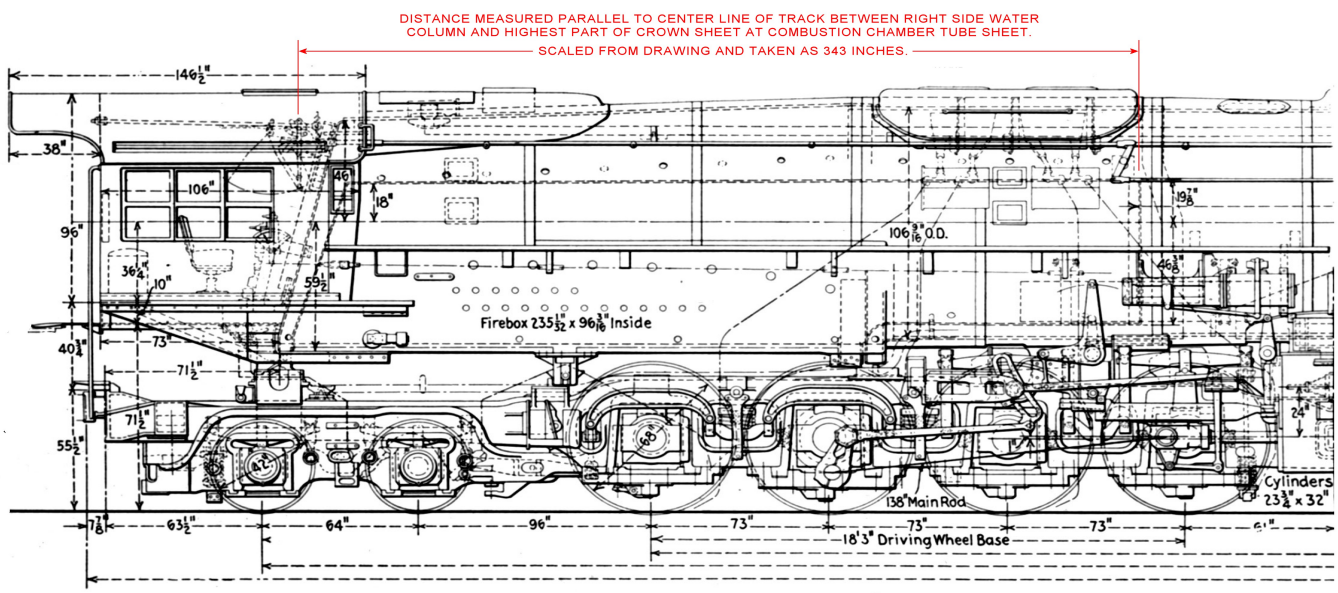
These locomotives are equipped with two water columns each having two standard-length water glasses, and the right-hand water column is provided with three gauge cocks. The height of water above the highest point of the crown sheet on level tangent track is 10½ in. with the water level in the boiler at the bottom gauge cock. Each pair of water glasses is applied with a vertical difference of 5½ in. in the lowest water-glass indication. The upper water glass is for indicating the height of the water in the boiler on level track or ascending grades, and the lower water glass is for indicating the height of the water in the boiler on descending grades.

Description above excerpted from Railway Age article originally published on October 4, 1941



Note: The upward angle of the camera produces parallax in the image that results in the appearance of the lowest reading of the right upper water gauge not being at the same elevation as the bottom gauge cock.

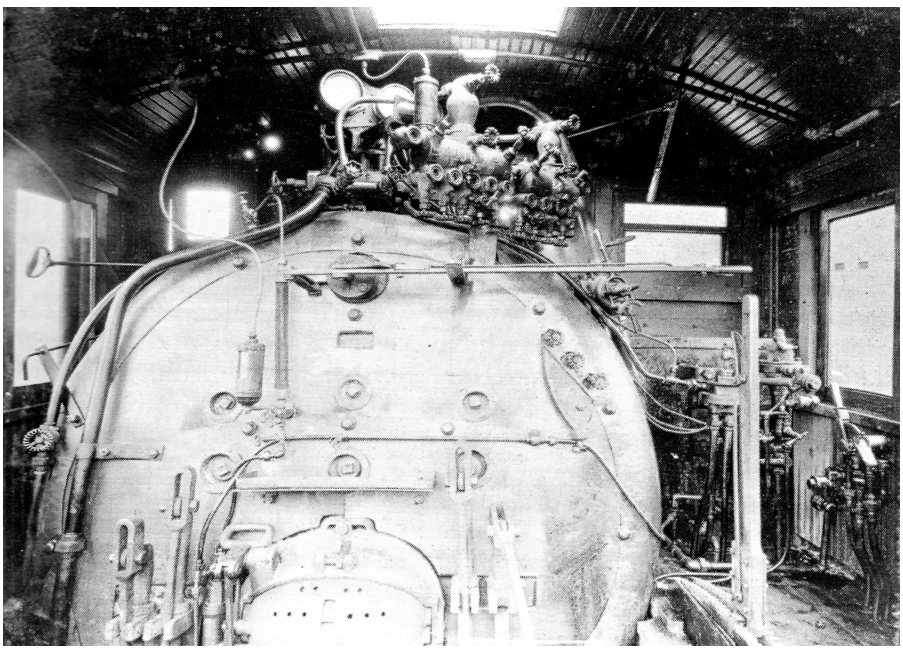
Locomotive on track gradient with smoke box up from when on level track. Track gradient in percent.	Depth of boiler water above highest part of crown sheet when boiler water level is at center of bottom gauge cock, in inches.	Depth of boiler water above highest part of crown sheet when boiler water level is at lowest reading of lower water glass, in inches.
0.00	10.500	5.000
0.50	8.785	3.285
1.00	7.070	1.570
1.25	6.213	0.712
1.50	5.355	0.000
2.00	3.640	0.000
2.50	1.925	0.000
2.75	1.068	0.000
		0.000 indicates highest part of crown sheet NOT submerged under surface of boiler water.

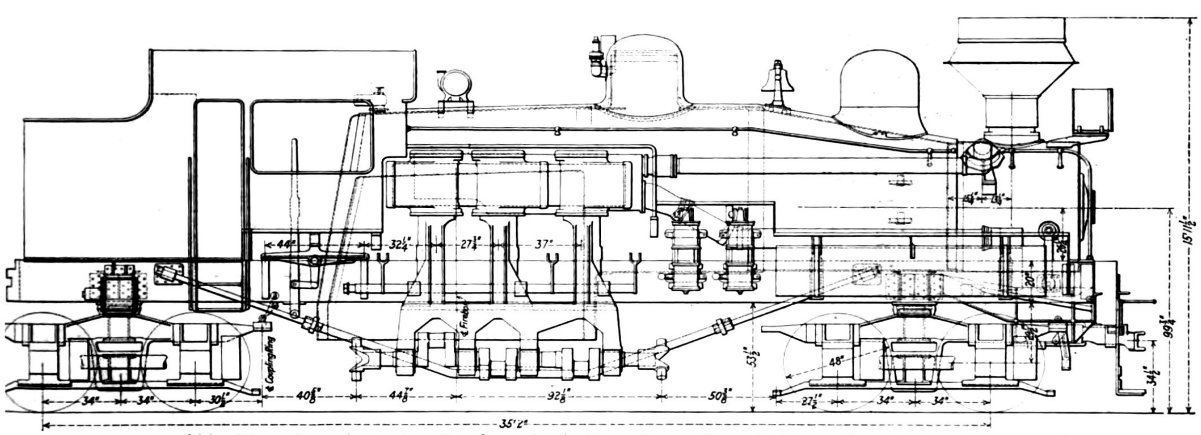


REAR PORTION OF UNION PACIFIC RAILROAD WASATCH CLASS 4-8-8-4 TYPE STEAM LOCOMOTIVE

GREENBRIER, CHEAT AND ELK RAILWAY 150 TON SHAY GEARED THREE-TRUCK TYPE LOCOMOTIVE No. 12

Image of boiler back head illustrating application of extended height water gauge that permits ascertaining of the level of water in boiler when it is above the highest gauge cock. Note the conventional application of the water gauge where its lowest reading is at the same elevation as the lowest or bottom gauge cock. Locomotive described as being for use on "Mountain Roads."





Side Elevation of Engine Portion of 150-Ton Shay Geared Three-Truck Type Locomotive.
Lima Locomotive Works, Inc.
Locomotive for the Greenbriar, Cheat & Elk Railway for use on Mountain Roads.

SOUTHERN PACIFIC RAILROAD CLASS AC-12 4-8-8-2 TYPE CAB FORWARD ARTICULATED STEAM LOCOMOTIVE No. 4294

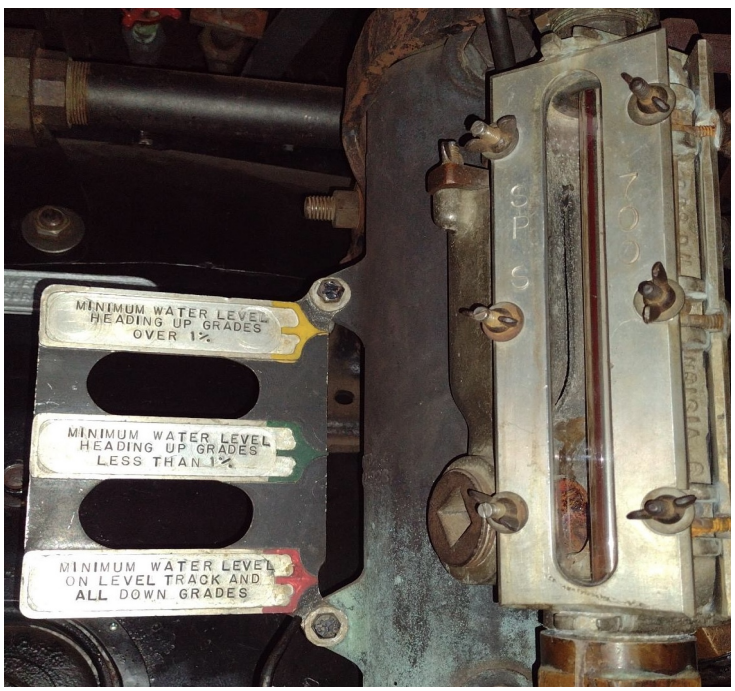
Image of fireman's side of boiler back head illustrating application of water gauge legend plate on which the upper horizontal cast line is labeled "DESCENDING GRADE" and the lower horizontal cast line is labeled "ASCENDING GRADE." The engineer's side water gauge also includes a legend plate labeled in a similar manner. These water gauge legend plates serve to remind the engine crew that the level of water that should be seen in the water gauge when a cab forward type locomotive is headed in the forward direction on either a descending grade or an ascending grade is opposite to that which should be seen in a water gauge of a conventional smoke box forward type locomotive when headed in the forward direction on either a descending grade or an ascending grade.

SPOKANE, PORTLAND AND SEATTLE RAILWAY CLASS E-1 4-8-4 TYPE No. 700

Image of boiler back head illustrating application of water gauge legend plate.

An additional arrow labeled “MINIMUM WATER LEVEL HEADING UP GRADES OVER 2%” is not included, therefore it may reasonably be assumed that the operating or motive power department of this railway was aware of the fact that within the territory that this locomotive would normally be expected to be in service it would not encounter an up grade of an amount steeper than 1% that would necessitate that such an additional arrow be affixed to the legend plate.

Image recorded by J. M. Signorini, circa 2025.



THE BALDWIN LOCOMOTIVE WORKS
ENGINEERING DEPARTMENT
PHILADELPHIA, PA.

STANDARD PRACTICE
SHEET 12-1 B
DATE 1-3-36

GAUGE COCKS

SUPERSEDING SHEET 32 12/9/21 & 12/4/26
SHEET 12-3 3/19/33, SHEET 12-3 1/19/34
APPROVED

BLW SPS 12-1B EXCERPT PRODUCED BY JGH 3-10-2019

ON ALL LOCOMOTIVE BOILERS, UNLESS OTHERWISE SPECIFIED, APPLY THE GAUGE COCKS ON THE RIGHT SIDE OF THE BACK HEAD, WITHIN CONVENIENT REACH OF THE ENGINEER.

WHEN GRADES ARE NOT SPECIFIED, THE GAUGE COCKS ARE LOCATED ABOVE THE CROWN IN ACCORDANCE WITH TABLE NO. 1,

WHEN GRADES LESS THAN 7% ARE SPECIFIED, THE GAUGE COCKS ARE LOCATED IN ACCORDANCE WITH SKETCH NO. 4, BUT NEVER CLOSER TO THE CROWN SHEET THAN SHOWN IN TABLE NO. 1,

ON LOCOMOTIVES WITH LONG FIREBOXES, TO OPERATE ON GRADES OF 6% TO 7%, RAISE QUESTION.

WHEN GRADES 7% AND OVER ARE SPECIFIED, THE GAUGE COCKS ARE LOCATED IN ACCORDANCE WITH SHEET [12-1D]

CONTINUED ON 12-1C.

THE BALDWIN LOCOMOTIVE WORKS
ENGINEERING DEPARTMENT
PHILADELPHIA, PA.

STANDARD PRACTICE
SHEET 12-1C
DATE 1-3-36

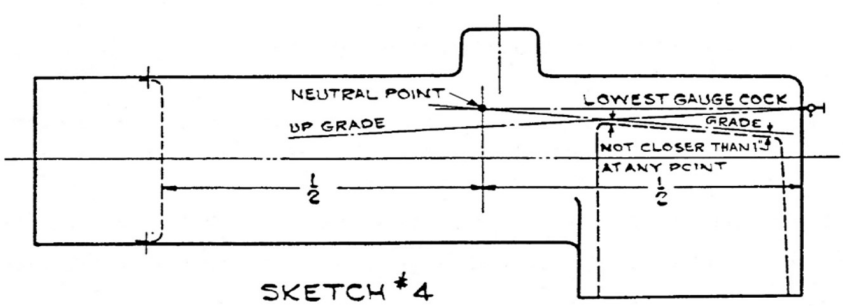
GAUGE COCKS

SUPERSEDING SHEET 32 12/9/21 & 12/4/26
SHEET 12-3 3/19/33 & 1/10/34
APPROVED

BLW SPS 12-1C EXCERPT PRODUCED BY JGH 3-10-2019

TABLE No.1

DIAMETER OF BOILER	LOWEST COCK ABOVE CROWN		VERTICAL DISTANCE BETWEEN COCKS A
	DOMESTIC	FOREIGN	
48" & OVER VERTICAL B.H.	3 1/4"	3 1/4"	3"
48" & OVER SLOPING B.H.	3 1/2"	3 1/2"	3"



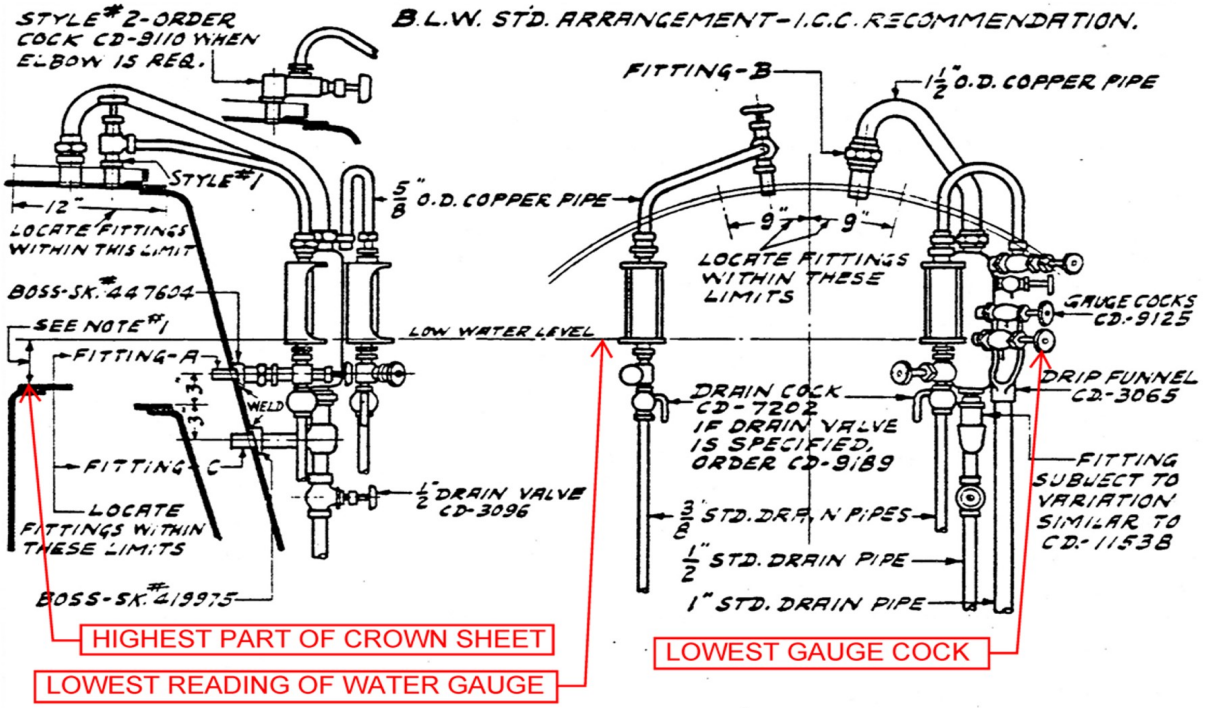
SKETCH #4

THE BALDWIN LOCOMOTIVE WORKS.
ENGINEERING DEPARTMENT.
PHILADELPHIA, PA

STANDARD PRACTICE
SHEET 12-4A
DATE 10-30-36
SUPERSEDING 1-15-35
APPROVED

WATER GAUGE & COLUMN

BLW SPS 12-4A EXCERPT PRODUCED BY JGH 3-10-2019



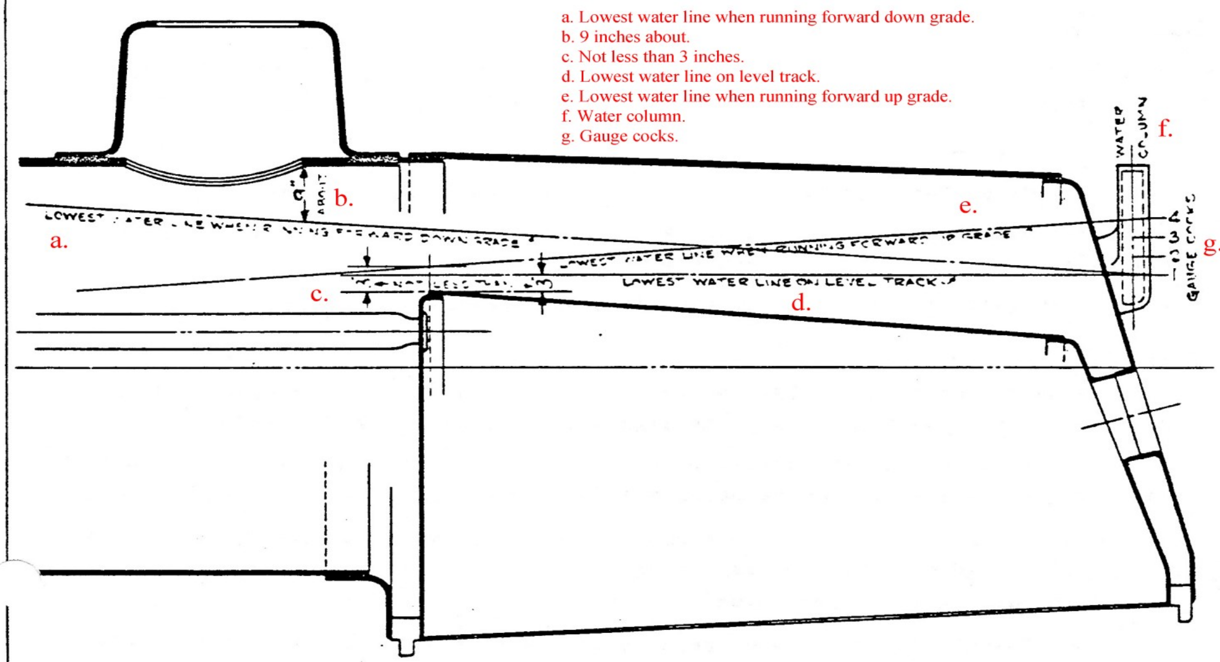
SUPERSEDED BY 12-1D

SUPERSEDED BY 12-1C

NOTE 1 - LOCATION OF GAUGE COCKS, WATER GAUGE & COLUMN - SHEETS 12-3 & 12-3A

THE BALDWIN LOCOMOTIVE WORKS ENGINEERING DEPARTMENT PHILADELPHIA, PA.	STANDARD PRACTICE SHEET **12-1D** DATE 1-3-36
LOCATION OF GAUGE COCKS – 7% GRADE AND OVER	SUPERSEDING TRAC. 66921 SHEETS 306 [illegible], 12-3A [illegible] & [illegible]
	APPROVED [illegible]

ANNOTATION IN RED BY JGH 3-10-2019



ON ENGINES THAT ARE TO BE OPERATED ON GRADES 7% AND OVER, THE GAUGE COCKS MUST BE LOCATED SO THAT WHEN ENGINE IS RUNNING FORWARD DOWN GRADE, THE WATER LINE WILL BE ABOUT 9" BELOW THE BACK EDGE OF THE OPENING IN THE BOILER UNDER THE DOME.

THE LOWEST GAUGE COCK TO BE LOCATED 3" ABOVE THE HIGHEST POINT OF CROWN WHEN ENGINE IS ON LEVEL AND HIGHEST GAUGE COCK LOCATED SO THAT THERE WILL BE NOT LESS THAN 3" OF WATER ABOVE HIGHEST POINT OF CROWN WHEN ENGINE IS RUNNING FORWARD UP GRADE.

GAUGE COCKS TO BE 3" APART. APPLY FOUR GAUGE COCKS IF GRADE IS STEEP ENOUGH TO REQUIRE MORE THAN THREE.

A PLATE TO BE PLACED IN THE CAB WHERE IT CAN BE EASILY READ BY THE ENGINEER, GIVING INSTRUCTIONS AS TO WHERE THE WATER LINE SHOULD BE WHEN THE ENGINE IS RUNNING FORWARD UP AND DOWN GRADE.

THE EXPOSED LENGTH OF THE GLASS OF THE WATER GAUGE MUST NOT BE LESS THAN THE DISTANCE BETWEEN THE LOWEST AND HIGHEST GAUGE COCKS.

THE LOWEST READING OF THE WATER GAUGE TO BE ON LINE WITH THE LOWEST GAUGE COCK.

THE GAUGE COCKS TO BE NUMBERED CONSECUTIVELY, COMMENCING WITH THE LOWEST AS No. 1.

THE WATER GAUGE TO BE MARKED WITH A LINE OPPOSITE THE GAUGE COCK BELOW WHICH THE WATER MUST NOT BE ALLOWED TO FALL WHEN ENGINE IS RUNNING FORWARD UP GRADE.