THE PENNSYLVANIA RAILROAD

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LOCOMOTIVE MAINTENANCE INSTRUCTION NO. L-65

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INSTRUCTIONS FOR STORING SUPERHEATER AND THROTTLE EQUIPMENT

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It has developed that some of our Class T1 locomotives that were in storage did not have the throttle valves and camshafts protected against corrosion. In order to prevent damage from this cause, the following instructions shall be observed when storing T1, Q1, and Q2 locomotives:

1. SUPERHEATER:

After boiler has been blown down, it should be washed, drained and filled while hot with air at 125 to 150 lbs. pressure. With inspection plugs in steam chest removed, cylinder cocks open and engine blocked, pull throttle wide open quickly. Throttle should be opened several times until no water comes out of inspection holes and cylinder cocks.

2. THROTTLE:

(a) - Remove outboard bearing, valves and shaft.
(b) - Coat outboard bearing with grease and wrap in cloth.
(c) - Coat valve seats and balancing piston guides with oil and replace valve covers. Close throttle shaft hole with wooden plug.
(d) - Coat shaft and valves with oil and store with bearing in place protected from the elements.

H. T. COVER.

ASST. VICE PRESIDENT-OPERATION
AND CHIEF OF MOTIVE POWER.

COPY ON FILE

From A. S. Vogt, Mechanical Engineer;
To J.T.Wallis, General Sup't Motive Power. Dated, December 30, 1915.

We have carefully noted Mr.Young's report, dated Nov.29, 1915, regarding a freight locomotive larger than the L1s, and, realising the great objection to a three-cylinder locomotive, have analyzed other means of accomplishing the same results. The objections to a three-cylinder locomotive are:

Crank axles;
Valve motion complications;
steam passage complications;
Inferior smokebox and draft conditions;
Increase of machinery.

The analysis of this subject shows that a two-cylinder locomotive can be designed to give all the advantages and none of the disadvantages of the proposed three-cylinder locomotive, and will furnish a greater uniformity of torque after the first revolution.

The problem presenting itself for consideration is to provide a 2-10-2 type of locomotive capable of furnishing 25 percent. more power than the L1s locomotive in starting and at speeds up to twenty miles per hour, for use on the Low Grade line between Harrisburg and Philadelphia. On this Division the ruling grade is 0.5%, and the locomotive power requirements are more uniform than on other Divisions, an ideal condition for a compound freight locomotive. The proposed locomotive should be as simple and economical as possible.

In the analysis of the above problem, the four-cylinder compound locomotive was eliminated on account of increase of machinery caused by the use of four cylinders and accompanying multiplication of other parts; also, because of cutting off steam at half-stroke in full gear in simple cylinders, the economy results are equivalent to a compound locomotive with a 2 to 1 ratio of cylinders.

Comparative theoretical calculations were made of the class L1s (2-8-2), the three-cylinder type (2-10-2A), and the two cylinder type (2-10-2B), on the following basis:

Type,	2-8-2	2-10-2A	2-10-2B
Number of Cylinders,	2	3	2
Size of cylinders, inches,	27 x 30	27 x 32	30 x 32
Boiler pressure, Lbs.per Sq.Inch	205	205	250
Diameter of drivers, inches,	62	62	62
Cut-Off, full gear,	.88	.50	.50
Boiler heating surface, Sq.feet	4800	5400	5400
Weight on drivers, pounds,	240000	300000	300000
Avg.Weight, Engine and Tender,	440000	500000	500000
Water, per hour,	55000	55000	55000

Note - Locomotive 2-10-2B must be equipped with starting-valve, on account of short cut-off in full gear.

From this tabulation it will be noted that, although the 2-10-2 locomotives are credited with 12-1/2% greater heating surface, the comparison is based on a flat rate of 55000 pounds of water per hour. This is done for the purpose of

clearly setting forth features of economy. At fifteen miles per hour and higher speeds, the 2-10-2 locomotives can furnish at least 10% more power than figures and diagrams indicate. Sheets 1 to 12 inclusive show the following:

Full gear starting and indicator cards;
Corresponding cylinder tractive power diagrams;
Cylinder tractive power and drawbar pull;
Indicated horsepower and drawbar horsepower;
Water consumption per indicated horsepower;
Water evaporated per pound pf coal;
Coal burned per indicated horsepower; and,
Coal burned per drawbar horsepower.

Corresponding tabulations are given on sheets numbers 13 and 14.

All of the results shown, including those for the 2-8-2 locomotive, are theoretical, for reasons of comparison.

At slow speed the tractive power is limited by the cylinder volume and maximum point of cut-off, and not by the amount of water evpporated by the boiler. The curves shown for tractive power and drawbar pull are the maximum. For speeds at which the tractive power is limited by cylinder volume and maximum cut off, 8% should be deducted for average values.

The results illustrated by the diagrams and tabulations of the 2-10-2A and 2-10-2B, show -

1 - That the ratio of maximum to minimum torque is the same for the two-cylinder and three-cylinder locomotives.
2 - The variation of torque is more gradual in the two-cylinder locomotive.
3 - A starting-valve and slightly larger cylinders applied to the three-cylinder locomotive will make that locomotive equal to the two-cylinder locomotive in cylinder tractive and drawbar power.
4 - At speeds up to eleven miles per hour the 2-10-2B locomotive will deliver at least 25% more drawbar pull per unit of water than the 2-8-2 when both locomotives are worked to their capacity.
5 - The saving of water and coal in favor of the 2-10-2B increases in proportion to the amount of water used per mile.
6 - On account of increased heating surface the 2-10-2B evaporates more water per pound of coal for the same amount of water per hour.
7 - The 2-10-2B locomotive shows 25% or more increase of drawbar pull per pound of coal for speeds up to 12 miles per hour, for 35,000 pounds of water per hour; 18 miles per hour, for 45,000 pounds of water per hour; and 25 miles per hour, for 55,000 pounds of water per hour.

The Profile of the Low-Grade, Phila. Division, shows approximately 38 mil of .3% grade. The fr length of freight haul, including cut-off, is 132 mile of which 94 miles averages slightly down-grade. The difference in elevation between Enola and Atglen is closely 200 feet. The total rise, due to 38 m of .3% grade is closely 600 feet. The total available time of run for one is 12 hours, allowing 1-1/2 hours for terminal delays, 1-1/2 hours for road stops, and 1 hour for unexpected contingencies, leaves 8 hours available run time.

The Middle Division maximum tonnage is 100 cars of 75 tons each, or 7500 tons. The total resistance of this train on level tangent is -

25,500	pounds	at	10	miles	per hour;
27,500	"	"	20	"	" "
33,200	"	"	30	"	" "

On .3% grade, the reistance is -

67,150	pounds	at	5	miles	per hour
68,500	"	"	10	"	" "
70,200	"	"	15	"	" "
72,500	"	"	20	"	" "

The maximum drawbar pull of the 2-10-2B locomotive, at 10 miles per hour, is 76,604 pounds. Taking 92% of this for average locomotive performance and subtracting 1500 pounds for gravity effect of locomotive and tender, leaves 68,976 pounds or, sufficient to take the designated train up a .3% grade at 10 miles per hour, at which speed the coal consumption is 5800 Lbs.per hour for full gear operation.

The coal consumption for the 38 miles of .3% grade is, therefore, 22,000 pounds during a period of 3.8 hours. The remainder of the run will have to be made in 4.2 hours, or at a speed of 23 miles per hour.

The available drawbar pull of the locomotive at 30 miles per hour is 34,718 pounds, at a water consumption of 56,000 pounds per hour, and the locomotive is capable of higher evaporation and consequent higher drawbar pull. The average train resistance at 30 miles per hour is less than 30,000 pounds.

From this it appears that when working the 2-10-2B locomotive to full capacity, the 7500-ton train can be hauled over the 94 miles at a speed of 35 miles per hour, or in less than 3 hours, or between 1 and 1-1/2 hours less time than required. At this speed the 7500 ton train on .08% average down grade, with an allowance of .6 pounds per ton for curvature, will require a water rate of 55,400 pounds per hour and a coal rate of 9600 Lbs.per hour. This would necessitate the use of a stoker.

At a speed of 23 miles per hour, making the run in the available time of 4.2 hours, the corresponding water rate would be 26,100 pounds per hour, and the coal rate would be 3300 pounds per hour. The coal requirements, therefore, would be 22,000 Lbs.for 38 miles of grade and 14,000 pounds for 94 miles, the remaining distance, making a total of 36,000 pounds for the whole run, an average of 45000Lbs.per hour, indicating that even with hand firing there is possibility of better performance.

A stoker can give no more power on the 38 miles of .3% grade than when firing by hand, as the maximum possible speed with the maximum train is between 10 and 11 miles per hour, at which speed the coal consumption cannot exceed 5800 Lbs.per hour, which is within the capabilities of a good fireman. On the remainder of the run the coal consumption need never reach 5000 pounds per hour.

For the same coal and water rates and corresponding maximum tractive power of 2-8-2 locomotive, the maximum train this locomotive can haul is only 6000 tons in 80 cars.

The starting power of the 2-8-2 locomotive corrected for .3% grade is 60,700 pounds, or 10.17 pounds per ton for the 6,000 tons train. This is barely sufficient to start the train, when bunched, on the specified grade.

The starting power of the 2.-10-2B locomotive corrected for .3% grade, is 99,000 pounds, or 13.2 pounds per ton for the 7500 ton train. To utilize this drawbar pull the rail must be sanded. With the train bunched the pull of 13.2 pounds per ton of train is sufficient.

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