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Locomotive Design and Construction from a Maintenance Standpoint.

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It is a question if there has ever existed a locomotive house foreman who has not, at some time or other, had the feeling that if some part of a locomotive had been designed a little differently, he could make repairs quicker, easier, and at less expense. While in many instances he may have been justified in this feeling, there are, however, cases influenced by other factors which may have been of greater importance from the standpoint of ultimate economy of operation.

The type and size of a locomotive have an important bearing on certain details of design. A discussion of the factors relating to the selection of the desired type and size is far beyond the scope of this paper, as it would involve a thorough consideration of the economics of railway operation. Some of these factors, usually considered from the standpoint of both present and future, are grades, track curvature, train speeds, train resistances, kind and nature of business, size and type of existing locomotives, transportation expenses, maintenance of equipment, and physical conditions, such as clearances, bridges, turntables, locomotive houses, repair shops, terminal and water facilities, etc. Occasionally certain of these factors may be such that some detail of the resulting design, while undesirable from a maintenance standpoint, is unavoidable. However, the majority of locomotive details are free from other than purely local restrictions and may be designed almost entirely from a maintenance standpoint.

It should not be inferred from what follows that mechanical and operating men, as well as locomotive builders, have not given a great deal of consideration to the points mentioned. Very many locomotives in service today bear witness of such consideration. However, there are at present justifiable reasons for emphasizing and reviewing the importance of locomotive design from a maintenance standpoint. Today, under changed conditions, the railways are being called upon to render greater service than ever before. But little new equipment is available other than that which the railways may build in their own shops. Repair shops are being worked to capacity. Skilled railway mechanics are scarce. Material of all kinds is difficult to obtain. All of which means that maximum service must be obtained from every bit of existing equipment. It is, therefore, essential to consider every legitimate means whereby the out of service period of a locomotive may be decreased and the in service period increased. All new locomotives should be constructed to give maximum service with minimum maintenance. All locomotives being rebuilt, or modernized, should be turned out of the shops prepared to give similar results. Any improvement that can be made to any locomotive, new, modernized, or under repairs, which will result in increased service, increased efficiency, or decreased maintenance, will help to increase the capacity of the railways. The following covers briefly a few of the points worthy of consideration:

Boiler.—It is hardly necessary to state that a well designed boiler of ample capacity is easier and cheaper to maintain than one of smaller capacity and which has to be forced continually. The importance of ample capacity can scarcely be overemphasized, either from a maintenance or operating standpoint. Within its limits of weight and size, a boiler should be designed to have a capacity as large as possible, consistent with other governing factors. In this connection the valves of the superheater, the brick arch, and the feed water heater are unquestionable. These values have been practically demonstrated from the standpoint of economy as well as locomotive capacity. The maintenance of locomotive boilers is an important factor, the greatest difficulties being leaky flues, leaky mud rings, broken staybolts, and cracks in firebox sheets.

Knowing that firebox heating surface does a great deal more work per square foot than flue heating surface, boiler capacity does not depend upon long flues. Short flues are the easiest to maintain. Flue location and spacing should be carefully considered, so as to permit easy maintenance, proper distribution of stresses, with a minimum amount of staying, and also to facilitate washing out, particularly in bad water districts. Many failures are frequently the result of crowding in too many flues, placing them too close to the heel of the flue sheet flange, and the use of too small a bridge. The flue sheet flange radius should be carefully considered in relation to the flue layout. Too small a radius, with flues located close to the heel, will not give as much flexibility as may be desired and will make the top flues difficult to maintain. Continued expanding of the flues will cause the sheet to flow, often resulting in flange cracks. The bead on the flues adjacent to the flanges should always rest on the flat surface of the sheet and never on the curved inside surface of the heel. With 2¼ in. or greater diameter flues it is best that the width of bridges be not less than ¾ in. Assuming that these points have been taken into consideration, it is important to see that the shop layerout and driller follow the design. There have been cases where a layerout has located flues incorrectly and also added one or more. It is also important that flue sheet holes be drilled the proper diameter as it is almost impossible to keep flues tight in holes that are too large.

The radii of door and back head sheet flanges should be studied in relation to the staybolt stresses. A moderately large back head sheet radius will reduce the stress in outer rows of bolts by transferring a portion of the load to the wrapper sheet. Too small a door opening radius will frequently result in cracking of the sheet at this point as provision is insufficient for expansion.

Mud ring corners of ample radius will be easy to construct and maintain. Trouble due to small radius has, in many instances, been overcome by electric or acetylene welding the bottom edges of the sheets at this point to the mud ring.

Flexible staybolts reduce staybolt breakage. A careful investigation will indicate the zones of maximum staybolt stress and sheet movement. In these zones the flexible bolts will give good results and reduce staybolt renewals.

Washout plugs should be so located that all points of the firebox and barrel can be easily reached with standard washout equipment.

Grates should have sufficient air space, be free as possible from dead spots, and be easy to remove. Where certain kinds of fuel are used, properly designed dump grates may be a means of reducing the time the engine is on the ash pit.

As far as possible, all brackets, clamps, or fittings applied on the boiler or firebox should be so located that staybolts, rivets, or portion of caulking edges will be accessible with a minimum of labor.

In connection with the barrel of the boiler, points which may be mentioned are—throttle and dome arrangement which will permit interior inspection of the boiler without the removal of the standpipe; also the elimination, as far as possible, of all small studs. The latter will apply equally to all parts of the boiler under pressure.

Expansion slides, instead of an expansion sheet, under the front of the mud ring, will eliminate the maintenance of a considerable number of bolts and rivets. Proper consideration of all other expansion sheets will further reduce maintenance of many bolts and rivets and tend to eliminate the many resulting troubles as well.

The front end, or smoke box, should be arranged to permit of access to all parts with the least possible work.

Frames should be of ample cross section and well braced to hold them rigid. Maximum cross section may be of little avail unless accompanied by sufficient and properly located bracing. In this connection, it hardly seems necessary to mention the advantages of a valve gear located outside the frames. The outside gear has made possible better frame bracing, to say nothing of the advantages of easier inspection and maintenance of the gear itself. As far as possible, bolt holes in frames should not be located where stresses are greatest. Where cylinder design will permit, a one piece frame with a top tie splice seems desirable. Where large cylinders prevent the above arrangement, a one piece frame with ample depth under the cylinders and having no reduction in thickness, will give excellent service.

Cylinders.—The advantages of outside steam pipes are self evident from the standpoint of both construction and maintenance. Cylinders should have saddle faces well bolted together to prevent working. All other things being equal a double row of bolts is better insurance than a single row. Weakening grooves cut in covers will reduce repairs to a minimum in case of failure.

Motion.—All bearing pressures should be as low as consistent with good practice