From "Red Devil and Other Tales from the Age of Steam" by David Wardale pages 494 and 496

Reliability

We have touched on this subject in Chapter 5 where it was stated that steam was the least reliable of the three major forms of traction. To understand this, a good yardstick of reliability must be given. The commonly used criterion was the number of train-km run per locomotive failure, the latter defined as a delay of specified duration, usually ten minutes or longer, attributable to the locomotive. This was similar to the layman's view of locomotive reliability and according to it steam performed well, but it was not a good measure for comparing the reliability of different types of locomotive. Essentially this criterion was one of service reliability based on punctuality, which in turn was dictated by commercial factors, because in order to satisfy customers, especially in a competitive environment, railways had to try to achieve a certain level of punctuality irrespective of the type of traction used. Thus service reliability was almost meaningless as a measure of locomotive reliability without relating it to the effort necessary to achieve the required quality of service. One of my superiors on BR once said that no machine is so badly designed that it cannot be operated, provided that its maintenance is good enough. Thus even quite imperfectly designed steam locomotives have been made to run with excellent reliability on the road at the price of enormous efforts from all concerned with operating and maintaining them. Porta gave the example of the Argentine Buenos Aires & Pacific Railway (later General San Martin Railway) using British locomotives built to early twentieth century standards for which the reliability index averaged 220 000 km per delay of more than ten minutes. Its express passenger 4-6-2's of 1925 were rostered to run 1 000 km trips and clocked up 20 000 km per month - very impressive figures indeed given the level of the technology - but Porta added that "it is known that every round trip the inside motion was disassembled and inspected!" In general the effort required to operate the timetable with steam traction was immense, as witnessed by the large number of depots and workshops necessary to service, maintain and overhaul the locomotives, not to mention the efforts required from the locomotive crews for lubrication and running maintenance.

The other reason why the definition in question did not accurately reflect locomotive reliability is that to maintain punctuality the schedules had to have allowances for, amongst other things, less than perfect locomotive performance, itself a manifestation of unreliability. Rare is the machine that functions perfectly as it should do and the 'normal' functioning of locomotives was certainly a good deal less than perfect, so a 'partial reliability factor' could be defined as the ratio of the actual performance of an average locomotive to its ideal performance. Locomotive performance deteriorated along the km run between overhauls due to wear and tear, and as the wear rates of steam locomotives were by far higher than for other types of traction it was the worst offender in this respect, with diesel traction being in turn worse than electric. The state of the boiler was an additional factor conditioning steam traction's performance. On p. 79 - 80 of Chronicles of Steam' E. S. Cox gives an interesting account of the defects found on locomotives which were "representative of the average condition in which a modern engine might be running at the general maintenance levels current [on BR] in the early fifties". The "considerable catalogue of ills" present in these locomotives resulted, for example, in an average of 10% loss of power compared to the 'as new' condition over wide ranges of speed and evaporation, whilst the maximum evaporation of one such 'rundown' locomotive was found to be lower than the rated value by as much as 27%. In addition a most important parameter affecting the scheduling of trains hauled by coal-burning steam locomotives was the relative unpredictability of their performance due to the effects on steaming of variations in coal quality and in the skill and motivation of the firemen. All these considerations combined to necessitate comparatively large allowances for less than perfect performance being incorporated into the schedules when using steam traction - a kind of 'factor of ignorance' concerning just how well any given engine and crew would perform. This was why when everything was 'just right' steam could better its schedules easily, much to the delight of amateur train timers who viewed what should have been everyday performances as some kind of exceptional feats, yet when things were at the other extreme 'tight' schedules could not be kept and the operating departments had to allow for this if punctuality was not going to suffer. Thus the reputation steam gained for reliability based on punctuality was achieved with schedules giving generous allowances for sub-optimum performance.

Another measure of reliability commonly used within railway administrations was the fraction of the total time for which a locomotive was available for traffic. The exact definition of available time varied but to be meaningful with steam traction it had to exclude all time required for planned maintenance, unplanned maintenance (running repairs), fuelling, watering (unless from water troughs), filling oil cups and other lubrication duties, fire-cleaning, ash disposal, fire preparation and steam raising, turning, and running light engine to and from facilities required for any of these. Given all this, steam appeared unreliable in “Operating's” eyes, yet it did not tell the whole story. The higher a locomotive's utilization the more maintenance and servicing it needed so the lower was the availability, and because of this linkage availability was not a good indicator of comparative reliability when utilization levels were different. For example a standby locomotive could record 100% availability but this only meant 100% reliability if it did not turn a wheel! Also as the servicing and maintenance requirements for steam were greater than for diesel and electric, and as some margin had to be given in turn-round times to allow for contingencies, the fraction of the available time for which a locomotive could be utilized was generally lower for steam than for the others.

In seeking a better criterion for locomotive reliability we need to consider the relationship between the normal functioning of a locomotive, the effort needed to ensure that normal functioning was obtained, and the time period for which both were considered. Clearly one trip was not a satisfactory time period and the matter should ideally have been considered over a locomotive's full life. Planned maintenance aimed to minimize the risk of total failure and keep the 'partial reliability factor' above the minimum value required to operate the service, whilst running repairs were by definition due to some kind of failure, be it even just a loose bolt. *The degree of maintenance therefore depended on a locomotive's inbuilt reliability, not the other way round, and the true criterion to be used for reliability was the overall effort, best measured by the total direct and indirect maintenance and servicing man-hours, required to provide the locomotive drawbar work necessary to punctually operate the train service.* The greater the total input man-hours the less reliable the locomotives concerned, and it was by this criterion that first generation steam traction was clearly the least reliable.

It can be argued that FGS was built according to the standards of its day and that its reliability cannot be compared with that of later diesel and electric traction. Certainly the first diesels were far from reliable, yet their reliability quickly improved to surpass that of contemporary steam because competition drove the diesel manufacturers to improve their products. Thus failures were properly investigated and designs altered accordingly. In the case of American manufacturers selling large numbers of locomotives with standard components, very thorough investigations into reliability were financed by the sales of thousands of locomotives, and the results benefited thousands more. This process was aided by what appeared to the layman to be one of non-steam traction's very weaknesses, the fact that a component failure often led to complete failure of the locomotive on the road. This proved to be a spur to development rather than a hindrance for as Porta once wrote "the ideal is a locomotive which does not run if not in proper running order", something which enforces measures to be taken to eliminate malfunctioning. Thus component failures on diesel and electric traction *had* to be cured, and to a great extent they were. On the other hand the ability of steam locomotives to get to the end of the line even with quite serious defects resulted in a comparatively lax attitude towards component performance that was fatal to the development of better detail design, the key to reliability. It can be said that in steam times the motive power organization supported problems rather than solving them, and the result was a cumulatively huge amount of fitter man-hours wasted at locomotive depots on such trivial tasks as tightening bolts that forever came loose - which cost the railways a lot of money.

As we have seen in Chapter 6.2 the Americans did more than anyone else towards improving the reliability of steam traction and their best locomotives achieved impressive results in terms of monthly distances run with a maintenance input that was presumably fairly modest, given the high cost of labour in the USA. This better reliability came at a price however, and ton-for-ton the construction of latter-day American locomotives was more expensive than that of, say, British ones, this probably being used by many administrations as one reason for not adopting American mechanical design features. If so this may well have been a mistake as (i) if locomotives were more reliable fewer of them were needed and (ii) over the full life of a locomotive its aggregate maintenance expense generally exceeded its capital cost. The case for designing and building locomotives for high reliability was therefore strong and became stronger as labour costs rose, and the failure of the steam locomotive industry as a whole to keep its detail design standards at least abreast of those in North America was a fatal error. American components should have worked even better in less mammoth locomotives generating lower forces (the magnitude of the loads on the driving, foundation and running gear on American locomotives having piston thrusts of up to 975 kN (100 tons) can well be imagined), yet the SAR 25NC class, which as we have seen was essentially a latter-day American locomotive in miniature, whilst more reliable than other SAR steam designs, was not up to the standards of almost contemporary diesel and electric traction by the criterion of reliability we have just established. Therefore even though the best of American detail design was good it had to la developed further, and could have been if those responsible for steam design had been more aware - aware that steam's reliability had to be better, aware of what their colleagues were doing in this field, and aware of related developments in other industries such as marine engineering where reliability had of necessity to be high.