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ROOT CAUSE OF UNDESIRED HOSE SEPARATIONS AND A SOLUTION

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ABSTRACT

Hose separations remain a significant problem for the class 1 railroads. They average about six thousand undesired hose separations a year. There are a lot of facts that the railroads are aware of, but lack good explanations. Why do more separations happen in the winter than in the summer? Why are old end hoses more prone to separation? Why does replacing the gaskets more frequently lead to a lower separation rate? Substantial research has been done to figure out the root cause of the undesired separation problem and to answer the above questions. The data analyzed from the class 1's has shown that the trolley arrangement accounts for 52% of the undesired separations. The force to move the end hose in a cushioned car trolley arrangement is sometimes greater than the force required to pull apart the gladhands. It is probable that misalignment of the gladhands, coupled with an end of car (EOC) arrangement that hinders smooth movement of the end hose, will lead to an undesired hose separation.

Research points to the fact that if there is a way that the force required to pull apart the end hose connections is kept greater than the force required to move the shackle on a trolley, then this will lower the frequency of undesired hose separations. By changing various characteristics of the gladhand gasket, it can be ensured that the pull-apart force is always around the 600lb range. These changes have been incorporated into the design of the double wide lip gasket and are currently in field testing. By reducing the occurrence of undesired end hose separations (UDEs), the amount of time a train is stopped can be greatly reduced.

INTRODUCTION

The main function of the end hose on a railcar is to provide a method for connecting the brake systems on two adjacent cars, enabling the brake signal to travel from the locomotive through the entire length of the train. The end hose uses a special fitting called a gladhand to maintain the connection between two adjacent trains. The design of the gladhand and the gasket within it allows the two end hoses to be coupled together easily, to be able to hold the trainline air pressure without leaking, and to allow uncoupling by pulling apart the endhoses with sufficient force.

The brake system on a railcar is designed as a fail-safe system. Any sudden loss of air pressure in the main trainline, including a separation of the train, will cause the brakes to be applied, bringing the train to a stop. Unfortunately, not all of the separations of the end hoses are planned. There are instances when the end hoses between cars become uncoupled for unknown reasons; these are known as UDEs. Data compiled by the class 1 railroads shows that the trolley arrangement is the most problematic, accounting for 52% of the undesired hose separations.

Undesired hose separations are a major problem for the railroad industry. Every time a UDE occurs, it causes a train to stop moving. These unplanned stoppages result in substantial loss in time from having to locate and re-couple the separation and wait while rebuilding brake pressure. This also results in additional train delays behind the stopped train, potential damage to railcars due to the emergency braking, wheel wear, associated repairs, and potential damage to the commodity being carried. The total estimated cost of these separations to the railroad industry is 15 million dollars a year. Undesired hose separations serve to drive down the average velocity of a train. When a UDE hose separation occurs, it costs the industry both time and money.

BACKGROUND

On cushioned cars, the EOC arrangement is designed to let the end hose move along the centerline of the car, depending on whether the car is in buff or in draft. When the arrangement does not allow the end hose to move freely, it results in a greater pulling force being applied to the end hose. The force to move the end hose is sometimes greater than the force required to pull apart and separate the gladhands [1]. This is especially true when the trolley arrangement has some defect or damage, whether it is weld splatter on the rod from repairs, for example, or damage from service. It has been believed that the gladhand gasket also contributes to UDEs. The force required for pull-apart using standard gaskets in gladhands that are *correctly* connected range from 250 lbs – 400 lbs (Fig. 1).

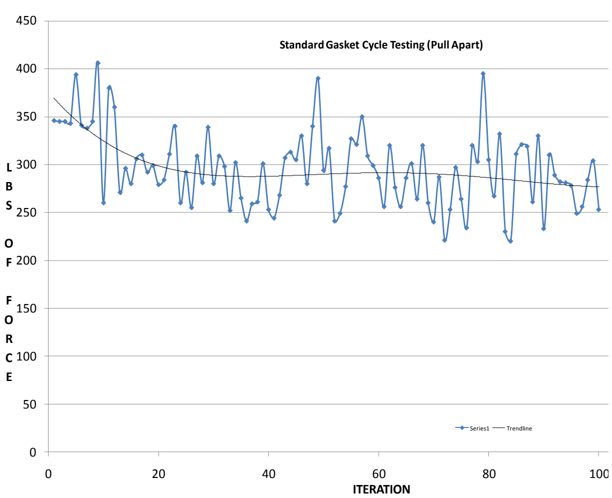


FIGURE 1: STANDARD GASKET CYCLE TESTING

However, if the gladhand gaskets were misaligned, it was theorized that the separation force could be much lower. Gladhand gaskets were believed to be able to roll and twist while holding air pressure and not maintaining their pull-apart strength. If a trolley arrangement should be coupled with a gladhand gasket connection that has not been properly aligned, this could lead to a situation where the required forces to pull the gladhands apart and to move the trolley overlap, thus resulting in a UDE (Fig. 2).

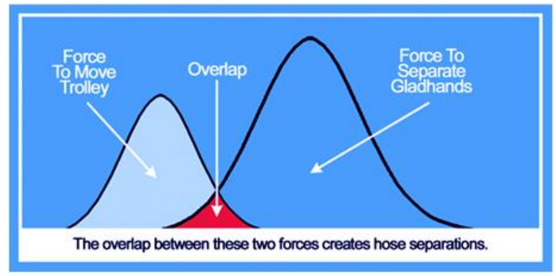


FIGURE 2: FORCE OVERLAP

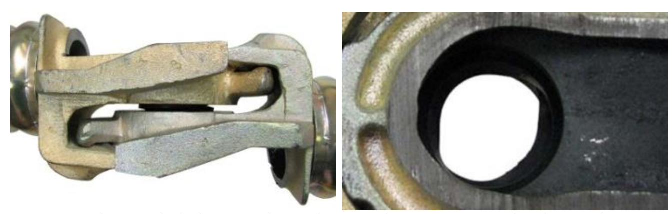
A study was conducted on the separation forces resulting from misaligned gladhands, and it was found that they can be less than the force required to move the shackle on a trolley. In turn, this led to the real possibility that misaligned gladhands can be a cause for UDEs.

New designs of the gladhand were studied to find one wherein the gasket does not roll or twist when coupled. They were also studied to ensure that the pull-apart force for the end hose assemblies always stays well above the maximum force needed to move a trolley arrangement. It was found that if these two conditions are met, the chance of a UDE is substantially reduced.

A new gasket was designed that prevents misalignment and also eliminated rolling and twisting in the gasket groove. The new design is meant to ensure that the pull-apart force is always around the 600 lb. range. This new gasket is now undergoing field testing via in-service freight cars.

MISALIGNMENT FINDINGS

It was observed at several railroad facilities [1], as well as demonstrated in the test lab, that a gladhand gasket can both roll and twist when two gladhands are coupled while still maintaining pressure (Fig. 3, 4)



FIGURES 3 & 4: MISALIGNED GLADHAND GASKETS

Lab tests were performed to determine the pull-apart force necessary for gaskets that have been misaligned. To determine the forces required, a simulation system was used where one end of a car was simulated by a fixed frame that followed the Association of American Railroads (AAR) S-4021 Specification [2]. The set-up had a load cell mounted to the end hose. The output was connected to a digital reader that logged the highest force measured. The adjacent car was simulated by a moving mechanism that simulates the structure of the AAR S-427 trolley specifications [3]. At the bottom part of the system two aluminum channels were positioned to simulate the rail. The heights of all the components related to top-of-rail were measured from the top surface of the channels. All dimensions and parts were designed and installed to follow AAR requirement S-427 [3]. A hydraulic cylinder was applied to drive the moving mechanism. The separation speed of the two hoses was set at about 1 mile/hour.

The test was performed with a person that was inexperienced with coupling together end hoses in order to repeat the chance of a misaligned gladhand in the real scenario. The end hoses were coupled together and separated a total of 100 times. Each end hose consisted of a gladhand, gasket, male pipe fitting, two ferrules and a hose blank. The hose blank met the AAR M-601 specification [4]. The end hose assemblies were from standard inventory. Each time the gladhands were separated, the maximum force required to pull apart the gladhands was recorded. It is evident from the test results (Fig.5) that there are many instances where the force required to separate the gladhands was substantially lower than the force that is commonly assumed to be needed to separate end hoses.

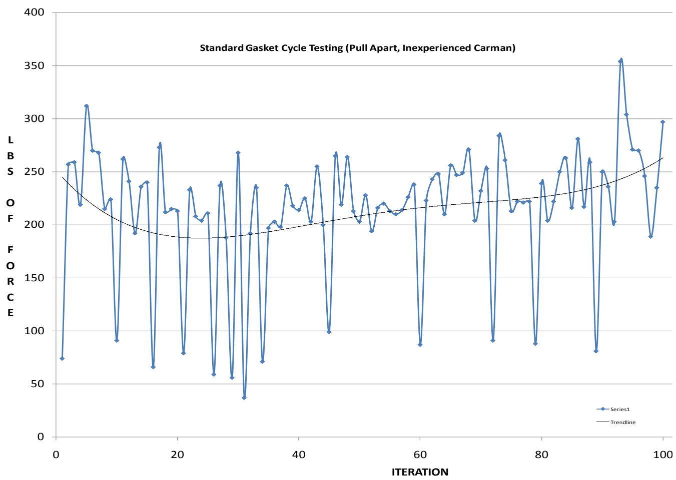


FIGURE 5: MISALIGNED GASKET CYCLE TESTING

The data gathered during this experiment confirms that the force required to pull apart end hoses is significantly lowered when the gaskets are misaligned.

PROPOSED SOLUTION

Gladhand gaskets can become misaligned easily with current dimensions. This is primarily due to the geometry of the gasket [5]. The current gasket can easily be moved and shifted inside the gasket groove. The proposed solution is to double the width of the gasket sidewall thickness (Fig.6) thus increasing its resistance to deformation when coupling two gladhands. This will also prevent it from being misaligned due to the larger surface area.


FIGURE 6: STANDARD GASKET VS. DOUBLE WIDE GASKET

The double wide gasket has a mating sidewall thickness of 0.312”, compared with the current sidewall thickness of 0.156”. The bigger sidewall gives the gasket added strength which prevents it from rolling and twisting in the gasket groove. It incorporates much more material than the current design, thus making it harder to roll and deform in the gasket groove.

The double wide gasket has a surface area of 1.470 in^2, compared to the 0.659 in^2 surface area of the current design. The increase in surface area prevents the gaskets from being misaligned, since the contact area is significantly greater than the amount the gasket can deform in the gasket groove. The greater surface area, coupled with a slightly lower durometer rubber, also results in greater adhesive friction between mating gaskets, helping them stay together. The inner diameter of the double wide gasket has not been changed; it is still 1 3/16” as noted in AAR requirement M-602 [5] to allow for normal air flow in the brake system. All of these factors should ensure that the pull-apart force for an end hose equipped with the double wide gasket is always around the 600lb range and never drops substantially, even with an inexperienced person coupling them.

Data that was gathered in a recent study [1] points to the fact that if there was a way that the force required to pull apart the end hoses was kept substantially greater than the force required to move the shackle on a trolley, this would lower the frequency of UDEs. By ensuring that the pull-apart force always stays around the 600 lb. range, it is believed that this will significantly diminish the amount of UDEs.

LABORATORY TESTING

All of the testing was performed using the same equipment as denoted previously in “Misalignment Findings”. The testing was set to run with blocks of 100 iterations each and several tests performed. The first test used two hose assemblies with the double wide gasket, being coupled by an inexperienced person. This person was not the same person that coupled the standard gaskets. When comparing the results of this test with the standard gasket results (Fig.7), it is evident that the new design maintains the force needed to uncouple the hoses at a safe level.

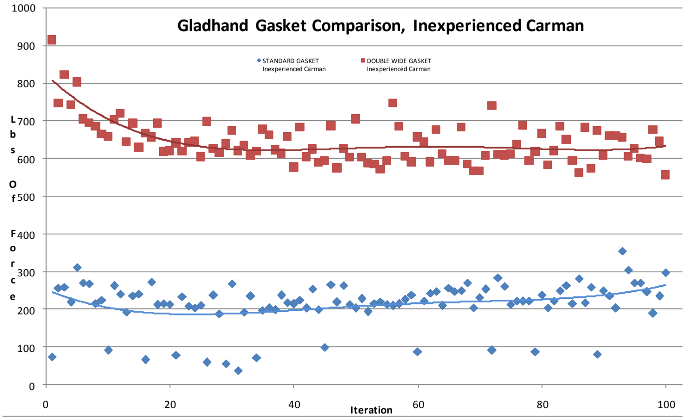


FIGURE 7: STANDARD VS. DOUBLE WIDE, PULL APART FORCE

Even with an inexperienced person, there were no instances where the hoses were coupled incorrectly with the double wide design. Even when the gaskets were slightly off center, there was still enough material making contact to keep the gaskets properly aligned, and to provide an adequate seal. There was no added difficulty in coupling the double wide gaskets when compared to the standard gaskets. The elimination of the misaligned gaskets, coupled with the improved geometry of the new gasket, resulted in a separation force that was consistently around the 600 - 700 lb. range.

The next test consisted of the double wide gasket remaining on the moving mechanism, and the fixed hose was replaced with a standard gasket assembly. This was to simulate the behavior of these two dissimilar hoses being coupled together in the field (Fig.8).

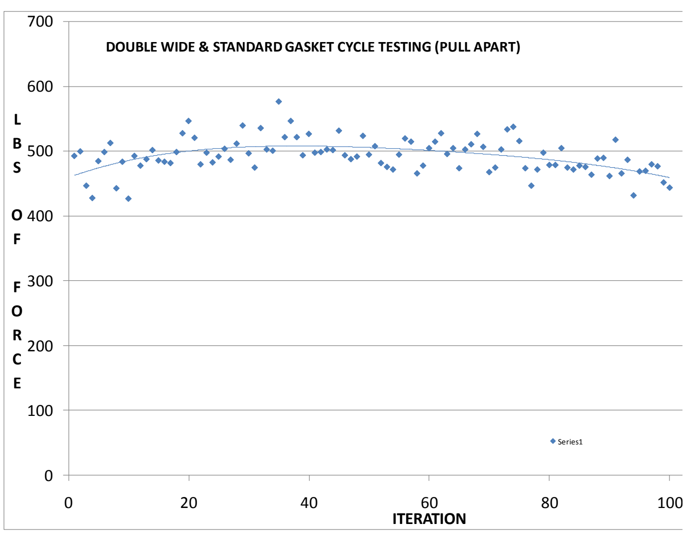


FIGURE 8: DOUBLE WIDE & STANDARD, PULL APART FORCE

When a standard gasket is coupled with a double wide gasket, the force is consistently around the 500 lb. range. Even though the pull-apart force was lower than two double wide gaskets, it was still substantially higher than the force required to moving a trolley arrangement. The behavior noted from the test was that when the standard gasket was misaligned with the double wide gasket, it would self-center and correct itself when the hoses were pressurized. This combination did not result in any misaligned gaskets. And the separation force was consistently around the 500 lb. range.

The next series of tests were a comparative of standard gaskets from two different vendors, the double wide & standard combination, and two double wide assemblies (Fig.9). All of the tests were repeated to verify their consistency.

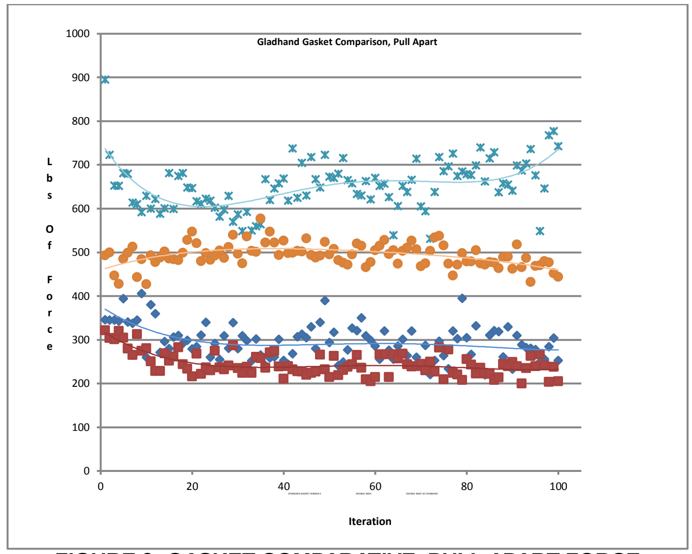


FIGURE 9: GASKET COMPARATIVE, PULL APART FORCE

The gasket comparative excluded any misaligned gladhands. It was done strictly to compare the pull-apart forces with good connections. This demonstrates the difference between the types of gasket connections. The higher values are directly linked to the double wide gasket. The standard gasket, even from different vendors, exhibited force thresholds that were lower than what was previously thought.

It has been shown that when gaskets are misaligned, the force required to separate the end hoses is substantially reduced. Introducing the double wide gasket, even when coupled with a standard gasket assembly, greatly increases the pull-apart force required. It also eliminates the risk of a misaligned gasket. In all of the testing that was performed, the double wide gasket has never created a misalignment.

When two double wide gaskets are coupled together, the gaskets do not misalign. The force to separate them is substantially higher than a regular gasket and this is reflected in the test data. Whenever the double wide gasket was used in testing, the pull off force required to separate the hoses never dropped below 400 lbs. The sidewall of the double wide gasket is much stiffer than a standard gasket and this helps it resist the rolling and bending motions that cause a regular gasket to misalign. The double wide gasket also allows for increased frictional forces between the gasket surfaces when separated, due to the increase in surface area. Normal frictional calculations ignore the role that surface area plays. This is due to the fact that the area of coverage of a sliding block is actually much larger than the area of contact. In rubber, however, its low elastic modulus results in a much greater area of contact at its interface [6], thus surface area plays a very big role. The increased surface area of the gasket will result in greater frictional forces between the gaskets when two end hoses are coupled together. The greater adhesive friction helps raise the force required to pull apart the hoses.

Raising the force required to separate the end hoses is very important, this will prevent the force required from going into the range of force required to move the trolley. Data that was gathered in field testing shows that the force to move the shackle on a trolley arrangement varies between < 1lb. to 63 lbs., with an average of 19 lbs [1]. This data was taken and then 10,000 instances were randomly generated that matched the logistic distribution of the field data. They also had the same parameters as the field data. The same random generation was performed using the data from standard gasket separations, as well as double width gasket separations.

By analyzing the trolley movement data together with the gasket separation data, there is a clear overlap where the forces required for both are the same. It is believed by the authors that this overlap is a cause of UDEs. Using the double wide gasket raises the pull-apart force well beyond the range that is necessary to move the trolley arrangement (Fig.10).

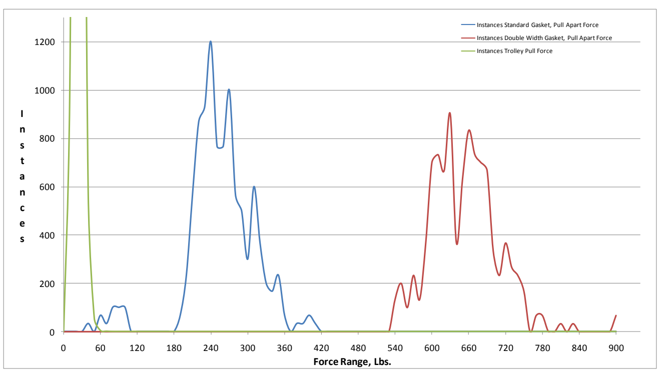


FIGURE 10: INSTANCES OF SEPARATION FORCE REQUIRED

The data represented in figure 10 is the count of how many times the force required to perform the specified action fell in a given range. The reason that the trolley pull data is spiked is because the force required to move the trolley falls in a very narrow range, from 0 – 70 lbs, while the force to separate end hoses has a much broader range. The data for the standard end hose forms a double bell curve because there are two distributions associated with it. The lower force range is associated with instances of misaligned gladhands. The second bell curve results from the force distribution associated with correctly connected gladhands. The data for the double wide gasket end hose does not form a double bell curve, because there are no instances of misaligned gladhands, or any other condition that would weaken the gladhand connection, occurring. The forces required to separate the standard gasket overlap with the forces to move the trolley in the 30 – 70 lb range. In the random simulation, there were a total of 10 instances occurring during the simulation for an average of 1 occurrence per 1000 instances.

This data matches up with the percentages of instances that are happening in the industry [1]. This data confirms that the problem lies within the gasket connection. The overlap between the standard gasket and the trolley movement force is very problematic. Raising the separation force beyond the range of the force required to move the trolley arrangement will greatly reduce the amount of undesired hose separations, as supported by testing.

FIELD TESTING

The double wide lip gasket has been well received by the industry. The representatives of TTCI, a few class 1 railroads, and Strato met in Strato's facility in June and discussed the undesired hose separation issue and possible solutions. After the demonstration of the misaligned gladhand connection and some tests, the group believed that this was the main reason behind the hose separation problem.

Many of the facts that the railroads are aware of, but lack explanation, can be answered by this finding. 1. Why do trolley arrangements have a much higher separation rate than fixed brackets? Because the end hose on a trolley arrangement is pushed or pulled to follow the cushion unit travel, but the end hose attached to a fixed bracket has almost no force applied to it. 2. Why do more separations happen in the winter than in the summer? Because the end hose and intermediate hose are stiffer under low temperature so a higher force is applied to move them, which increases the chance of a separation. 3. Why is it easier to have separation on old endhoses? Because the more wear the gaskets and gladhands have, the easier it is to misalign the connection between to end hoses. This is also why replacing the gaskets more often can help the separation rate. 4. Why can a separation not be intentionally repeated on the same cars? Because, according to figures 5 & 7, the chance is 10-15% that a bad connection will result for an inexperienced person, i.e. 85-90% of the time, a bad connection will not be repeated.

The design of the double wide lip successfully eliminated the chance of a misalignment. All the problems mentioned above, therefore, can and will be solved. The design has been reviewed by the AAR Brake Systems Committee (BSC) and a test allotment has been assigned. There are currently a total of 100 rail cars, a combination of bi-level and tri-level auto racks, on field test. They originated in Portland, Oregon, where they were inspected and equipped with the double wide gasket and gladhand between the dates of 04/30/09 and 05/15/09/. The car numbers have been recorded and the number of UDEs they experience is being tracked.

The proposed plan was to keep as many vehicles running in groups of 30 between Portland, Oregon (PNW) and Logistics Park in Chicago, IL. for one full year. This would allow the difference to be noted in various weather conditions. The cars were only able to be kept together for a few cycles between the two points as described in the plan. Since this time, the vehicles have been interchanged off-line to other railroads and are now in service and mixed with other vehicles equipped with the standard gasket. As of this point, none of the vehicles equipped with the double wide gasket have been involved in a UDE. There have been three cars that required air hose support adjustments. There have been no other findings at this time. The vehicles will continue to be monitored over the next nine months and more data will be gathered. Further discussion on this topic will be taking place at the AAR Brake Systems Committee meeting that is scheduled for the week of August 24th.

DISCUSSIONS & CONCLUSIONS

After analyzing data supplied by the class 1 railroads, it was discovered that the trolley arrangement was responsible for the majority of the UDEs. Extensive research was performed to discover the root cause of the UDEs. The data gathered pointed to the fact that the force required to separate the end hoses can vary greatly. It was always assumed that this force was around the 400 - 600 lb range. Testing discovered that this force was seldom this high. The real range is from 250 to 400 lbs. And it can drop well below this range.

The root cause of this variance was found out to be misaligned gladhand gaskets. Misaligned gaskets can drop the force required for pull apart from the 250 - 400 lb range down to as low as 30lbs. This discovery led to the theory that misaligned gaskets led to the UDEs. The testing performed on the trolley movement force showed that the force to move a trolley can vary from 0 - 63 lbs. This testing did not even take into account trolley arrangements that were bent, had weld splatter on the rod, or otherwise were not in good working condition [1].

The summation of all the testing is that there is a range, from 30 lbs. to 63 lbs., that the force required to move the trolley arrangement could be greater than the force required to separate the two end hoses. In the field, this could lead to an UDE. The solution to this problem was to keep the force required to separate the end hoses well above the force required to move the trolley arrangement.

The double wide gasket removes the possibility of a misaligned gasket, and thus always maintains the force required to separate the end hoses to a level well above the trolley force. Field testing thus far has shown that, when using the double wide gasket, the number of UDEs is greatly reduced. This validates the theory of the primary cause of UDEs. By significantly lowering the occurrence of UDEs the incidence of train stoppages will be reduced, thus driving average velocity, and increasing the efficiency of the railroad.

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