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ABSTRACT

In recent years, high-speed oval track racing has become one of the most popular sports in the country, especially with regards to the NASCAR and Indy Racing Leagues. In general, typical oval track raceways have used reinforced concrete outer walls for containment of the high-speed race cars. While these concrete walls provide effective containment of errant vehicles, their rigidity has led to many serious injuries and fatalities. Recently, an energy-absorbing barrier was developed by the Midwest Roadside Safety Facility at the University of Nebraska - Lincoln to mitigate the severity of impacts with the outer containment walls. The new barrier, known as the Steel And Foam Energy Reduction (SAFER) Barrier, consists of a high-strength, tubular steel skin that distributes the impact load to energy-absorbing foam cartridges in order to reduce the severity of the impact, extend the impact event, and provide the occupant of the race car additional protection.

Currently, the SAFER barrier has been installed at a large number of race tracks across the country. A significant number of impacts involving both NASCAR and IRL vehicles have occurred into the various SAFER barrier installations. Impact data from these events has been collected by the safety personnel in the motorsports organizations and provided to the designers of the SAFER barrier. This accident data was then compared with the data from similar impacts on unprotected concrete walls in order to provide a real-world performance evaluation of the SAFER barrier. Analysis of the crash data demonstrated that the SAFER barrier provides a substantial decrease in impact severity and potential driver injuries over impacts with an unprotected concrete wall.

INTRODUCTION

In recent years, automobile racing has become one of the most popular sporting venues in the U.S. as well as internationally. This fact can be seen by the variety of race series available for both drivers and spectators, including Formula 1, the Indy Racing League (IRL), CART, NASCAR, and IROC to name a few. For most of these race series, high-performance cars and trucks travel several hundred times around oval-shaped tracks at very high speeds. For larger ovals, which include banked corners, speeds for open-wheeled vehicles can reach 370 km/h (230 mph).

While significant safety advances have been made over the years in the areas of driver restraints and vehicle crashworthiness, the development of safety devices for the raceway structure itself has been largely unchanged. Vehicular containment on oval tracks is typically provided by rigid, vertical concrete walls placed around the exterior of the racetrack. These barriers are primarily designed to protect spectators from errant vehicles. Although these containment barriers have been utilized for many years, serious driver injuries and fatalities during crashes continued to occur. Therefore, there existed a need to provide improved safety for those participating in the sport of auto racing.

In 1999, IRL (and in subsequent years NASCAR) contracted the Midwest Roadside Safety Facility (MwRSF) at the University of Nebraska - Lincoln to develop a safety barrier for high-speed oval racing. The new barrier was developed to meet several design criteria. First, the new barrier had to be capable of reducing lateral decelerations without significantly increasing longitudinal decelerations, those occurring as a result of vehicle gouging and snag into the barrier. Second, the barrier had to be modular in design in order to increase constructability. Third, the barrier could not require significant down time for making repairs following a crash event. Finally, the barrier had to remain intact following an extreme crash event and not result in debris scattered across the track.

Over the course of the next five years and following 26 full-scale vehicle crash tests, the Steel And Foam Energy Reduction (SAFER) barrier was developed, as shown in Figure 1 [1-3]. The SAFER barrier is a safety barrier that reduces the severity of impacts between the race vehicles and the walls of the raceway by absorbing energy, extending the duration of the impact event, and providing more opportunity for the driver restraint systems to function.

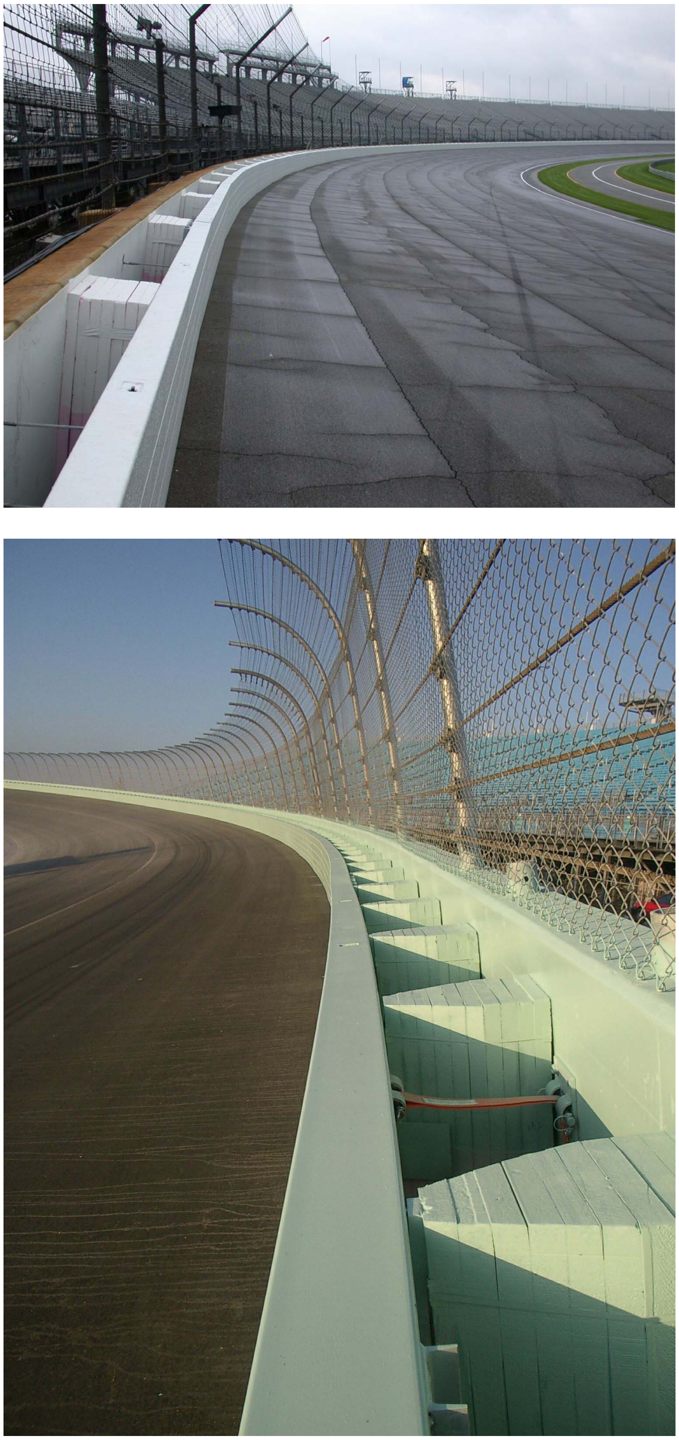

FIGURE 1 SAFER Barrier

The performance of the SAFER barrier was validated by the researchers through computer simulation modeling and full-scale crash testing using both NASCAR and IRL vehicles. This program included high-speed tests at speeds and angles in excess of 241 km/h (150 mph) and 25 degrees, respectively. While this research demonstrated that the SAFER barrier could significantly reduce vehicle decelerations as well as the impact forces imparted to the driver, it was not possible for the researchers to investigate the complete range of possible impact conditions the system might face under race conditions. Therefore, it was imperative that the SAFER barrier be subjected to a real-world, in-service performance evaluation in order to insure that it was functioning properly and that no unexpected problems arose under impact scenarios not investigated in the laboratory.

To date, the SAFER barrier has been installed at twenty tracks used by the NASCAR and IRL circuits, and plans are currently in place to have the barriers installed at all tracks holding NASCAR race events by 2005. MwRSF, with cooperation from NASCAR and IRL, has been monitoring the major impacts with the SAFER barrier since its initial installation in April of 2002. The research presented herein details the in-service performance evaluation of the SAFER barrier over the past three years.

SAFER BARRIER DESIGN DETAILS

Currently, there are two versions of the SAFER barrier installed at the various race tracks around the country. The Indianapolis Motor Speedway in Indianapolis, Indiana had the original version of the SAFER barrier installed in April of 2002 prior to the running of the Indianapolis 500. This version of the SAFER barrier was also installed along one of the inside walls at the Talladega Superspeedway. All of the other SAFER barrier installations, as well as future installations of the barrier, use an improved, second generation design. Both designs use similar components and function in a similar manner. There are four main components in the SAFER barrier system: (1) a rigid, tubular steel impact plate that serves as the main interface between the impacting vehicle and the barrier, thus providing a smooth profile for redirection of the vehicle and distribution of the impact load to the energy absorbers; (2) a series of splice tubes used to rigidly connect adjacent sections of the tubular steel skin; (3) foam energy absorbers for dissipating a portion of the vehicle's kinetic energy; and (4) retention devices for maintaining the attachment to the outer concrete wall.

ORIGINAL SAFER BARRIER DETAILS

The original version of the SAFER barrier installed at the Indianapolis Motor Speedway is shown schematically in Figure 2. The barrier was 521-mm (20.5-in) thick and consisted of 6.10-m (20-ft) long modules composed of two 152-mm x 203-mm x 4.76-mm (6-in. x 8-in. x 3/16-in.), one 152-mm x 254-mm x 4.76-mm (6-in. x 10-in. x 3/16-in.), and one 152-mm x 305-mm x 4.76-mm (6-in. x 12-in. 3/16-in.) rectangular structural steel tubes skip-welded together to a total height of 965 mm (38.0 in.). The tubes were galvanized and painted with a low friction paint to reduce friction between the barrier and the impacting vehicles. Four internal stiffened steel splices connected each of the modules together with bolted fasteners, thus transferring the moment, shear,

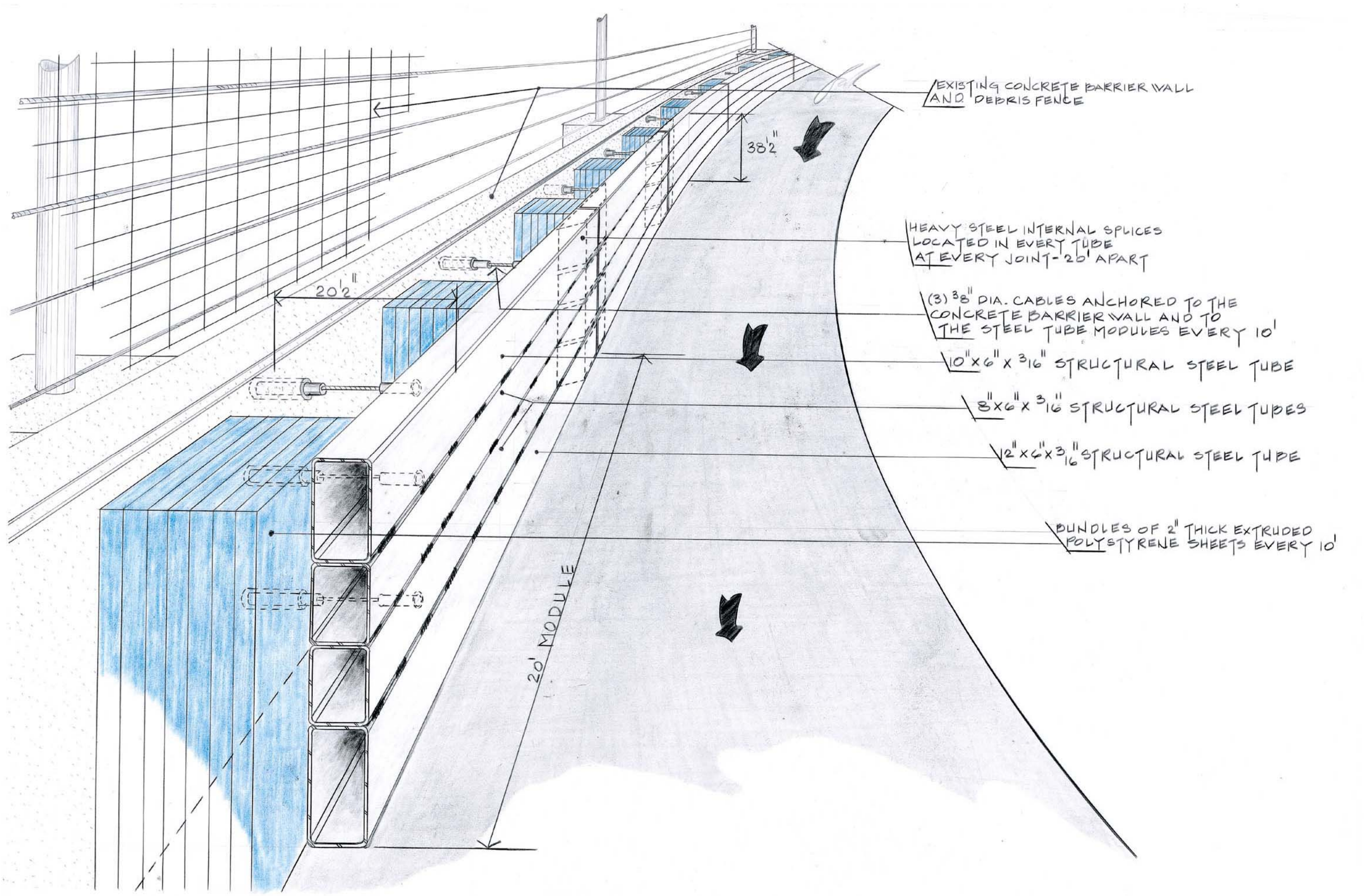

FIGURE 2 Original SAFER Barrier Design (Courtesy of the Indianapolis Motor Speedway and the Indy Racing League)

and axial loads between adjacent sections. A series of 508-mm (20-in.) wide by 356-mm (14.5-in.) deep by 1,106-mm (40-in.) tall cartridges, comprised of extruded polystyrene foam, were placed between the existing concrete wall. The cartridge spacing along the wall varied depending on the particular type of vehicle racing. For the heavier NASCAR vehicles, the foam cartridges were spaced 1,524 mm (60 in.) on center along the wall, while the foam spacing for the lighter, open-wheel IRL vehicles was increased to 3,048 mm (120 in.). Finally, two 9.53-mm (3/8-in.) diameter cables were used to anchor the steel impact plate to the concrete wall using a 3-m (10-ft) center to center spacing.

CURRENT SAFER BARRIER DETAILS

Shortly after the installation of the original SAFER barrier, an improved version of the system was designed and tested in order to address three additional design considerations not accounted for in the original design. The additional design considerations consisted of the following: (1) incorporation of curved wall sections rather than the straight panels used in the original wall in order to allow for installation of the barrier on short-radius tracks; (2) development of a more secure attachment of the steel impact plate to the concrete wall; and (3) development of a single foam energy-absorber configuration for both race vehicle types.

The redesign of the SAFER barrier led to three main design changes, as shown in Figures 3 through 5. The first modification incorporated a change in the tubular steel impact plate. The new impact plate was comprised of five 203-mm x 203-mm x 4.76-mm (8-in. x 8-in. x 3/16-in.) steel tubes skip-welded together to a total height of 1,016 mm (40.0 in.). The tube size was increased to handle the higher impact loads imparted to the barrier due to the increased curvature of the barrier. The length of the impact plate sections was increased to 8.53 m (28 ft), and the middle 6.40 m (21 ft) of each section was curved to match the track radius. A length of 1.07 m (3.5 ft) on each end was left straight to accommodate the splices between adjacent sections. A new connection between the impact plate and the outer concrete wall was also developed. The new connection consisted of a high-strength, nylon strap connected to the impact plate and the outer concrete wall using quick-release, high-strength, corrosion-resistant, alloy pins and adjustable steel mounting plates. This connection method provided easier installation as well as improved dynamic load capacity over the steel cables used previously. Finally, the energy-absorbing foam cartridges were modified by increasing the depth of the cartridges

FIGURE 3 Tubular Steel Impact Plate Modifications

FIGURE 4 Barrier Retention Straps

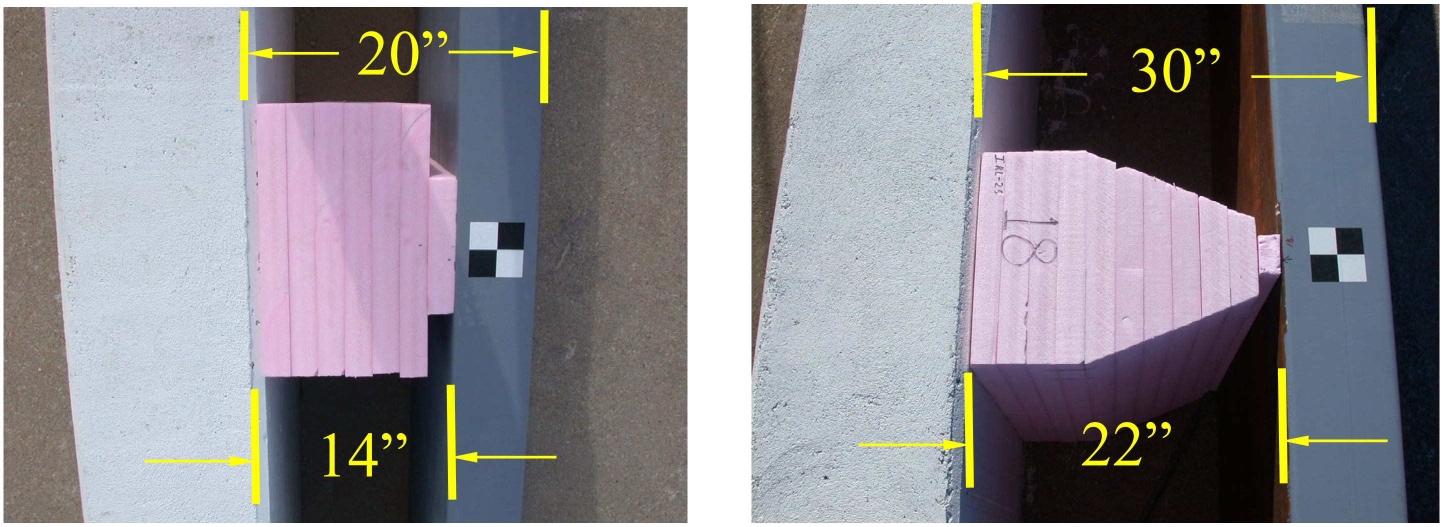

FIGURE 5 Foam Cartridge Modification

from 356 mm (14.5 in.) to 559 mm (22 in.) and changing the shape of the blocks from a rectangle to a trapezoidal shape with a tapered front. The new cartridge design provided lower loads for the lighter, IRL vehicles during the initial crush of the foam, while still providing sufficient energy absorption for impacts with the heavier NASCAR vehicles. The new foam cartridges were spaced 1,707-mm (67.2-in.) on centers.

This improved version of the SAFER barrier has been and will continue to be installed at all race tracks where its implementation is recommended.

SAFER BARRIER OPERATION

The function of the SAFER barrier is shown in the sequential photographs in Figure 6. During a crash event, a vehicle impacts the tubular steel impact plate which causes it to move laterally towards the outer concrete wall. As the impact plate deflects, the impact load is distributed to the energy-absorbing foam cartridges. Deformation and crush of the foam cartridges absorbs a portion of the kinetic energy of the impact and lowers the impact loads imparted to the vehicle and the driver. As the barrier crushes the foam, the vehicle is redirected toward the track at a shallow angle. Eventually, the vehicle disengages from the barrier, and the retaining cables or straps act to keep the barrier fixed to the outer concrete wall. The SAFER barrier was designed to retain its integrity under worst-case impact scenarios. For most real-world impacts, the SAFER barrier requires almost no maintenance during and after a race. Generally speaking, in the most severe impact events, the SAFER barrier can be repaired by simply replacing the foam cartridges in the impact region.

IN-SERVICE PERFORMANCE EVALUATION

The objective of this research was to investigate various real-world impacts with the SAFER barrier in order to evaluate its safety performance under actual race conditions and its effect on driver safety. A large number of high-speed oval racing accidents involving both NASCAR and IRL vehicles were examined both with and without the SAFER barrier installed. Data from these accidents, including accelerometer measurements, impact conditions, driver injuries, and SAFER barrier damage was obtained so that comparisons could be made between impacts on concrete walls versus the SAFER barrier. For discussion purposes, the most pertinent comparisons are divided into IRL vehicle impacts and NASCAR vehicle impacts. While there were a large number of impacts analyzed during the course of the research, many of these events were not deemed significant in terms of overall impact severity. The accidents described herein demonstrate the more violent impact events and the performance of the SAFER barrier in those impacts. Due to concerns involving driver privacy, specific details of the impact events, including driver names, dates, track names, and car numbers, will not be provided in this paper. Instead, the impact events were described using a letter reference for the driver and a general track description.

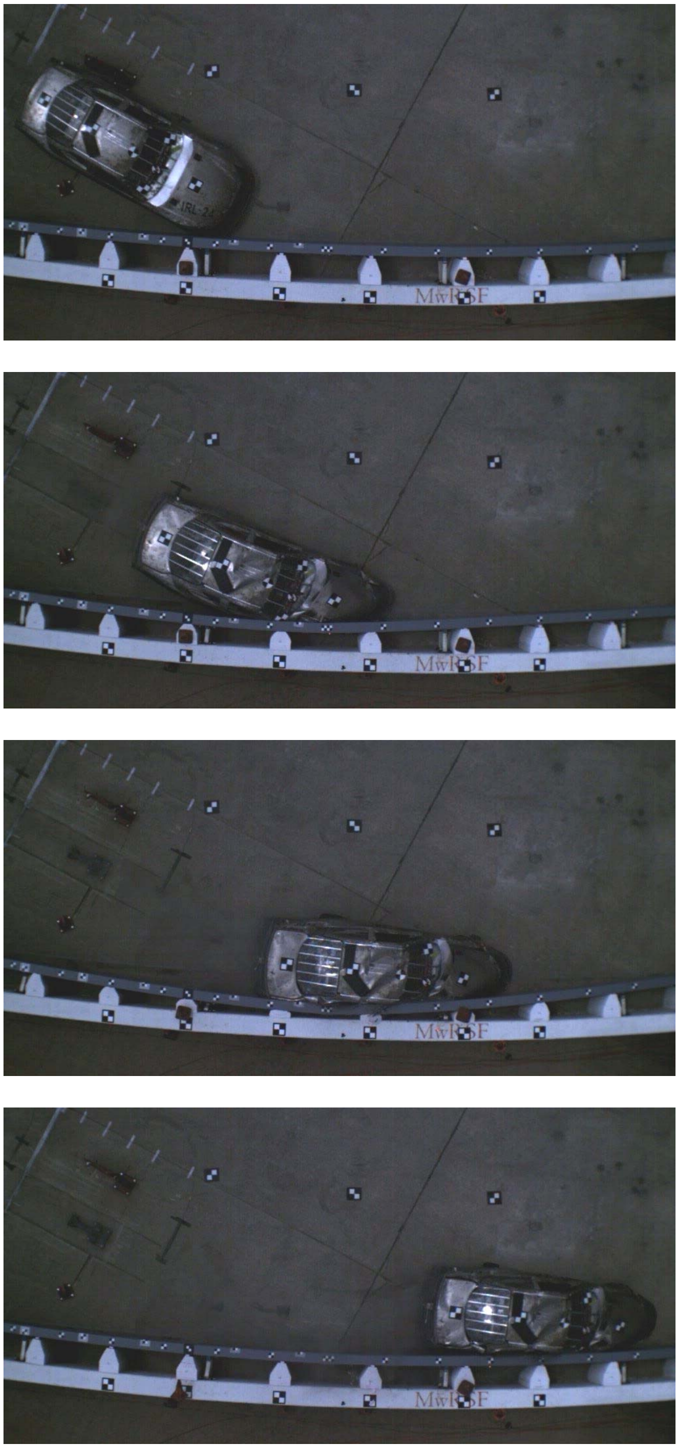

FIGURE 6 SAFER Barrier Impact

IRL SAFER EVALUATION

Rearward Impacts

The first real-world test of the SAFER barrier came soon after its initial installation. During a round of testing at a 4.0-km (2.5-mile) oval track, Driver A lost control in turn three, and his car spun and impacted the wall in a tracking, rearward trajectory, as shown in Figure 7.

Impact conditions for Driver A's crash event were estimated to be a speed of 290 km/h (180 mph) and an angle of 19 degrees. The car impacted the SAFER barrier, spun the front of the vehicle toward the wall creating a second impact, and then slid downstream along the wall before coming to rest. Driver A was uninjured other than a minor injuries to his right leg and was able to walk away from the accident. He was able to resume testing days later and race in the Indianapolis 500.

FIGURE 7 Driver A Impact

For comparison purposes, a similar crash event occurred at the same 4.0-km (2.5-mile) oval track involving Driver B. Driver B lost control of his race car in turn one and impacted the outer concrete wall with a rearward orientation at an estimated speed and angle of 290 km/h (180 mph) and 19 degrees, respectively. A comparison of the longitudinal vehicle accelerations from the Driver A and Driver B impact events is shown in Figure 8. A review of the accident data clearly showed the benefit of the SAFER barrier in mitigating the impact on Driver A's vehicle as the peak accelerations were reduced approximately 60 percent from those observed in the Driver B crash. In addition, the SAFER barrier extended the time of the impact event for the Driver A crash which provided improved opportunities for the occupant restraint systems to protect the driver. These benefits were reflected in the injuries sustained by both drivers. As noted previously, Driver A sustained minor injuries, while Driver B was knocked unconscious and suffered a severed vertebral artery, a potentially fatal injury that required emergency surgery. Driver B was not cleared to race again for several months.

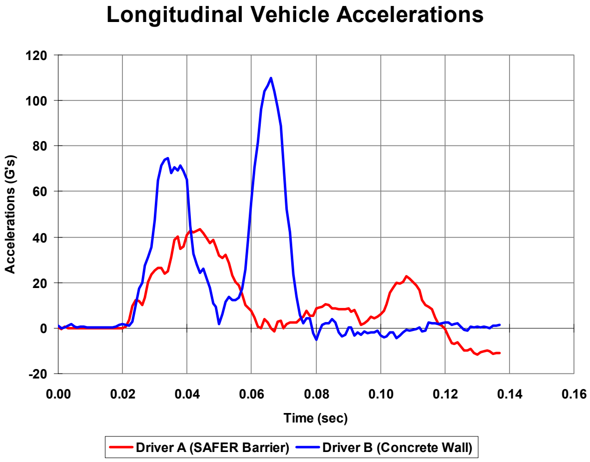

FIGURE 8 Driver A and Driver B Impact Comparison

Frontal, Oblique SAFER Barrier Impact

Further demonstration of the SAFER barrier's performance was given in a severe crash involving Driver C. Driver C was conducting private testing at a 4.0-km (2.5-mile) oval track when the vehicle lost control and impacted the SAFER barrier in turn three. While the exact impact conditions for the crash were unavailable, the severity of the impact was very high. According to eyewitness reports, Driver C's car impacted the wall at a high speed and a very high impact angle. This observation was verified when the researchers examined the accelerometer data from the impact, as shown in Figure 9. Velocity data taken from the accelerometers on Driver C's car displayed a resultant change in velocity (resultant delta v) of approximately 57.9 m/s (190 ft/s). A change in velocity of this magnitude represented one of the more severe impacts achieved in a racing environment. For example, the resultant change in velocity for the Driver A and Driver B impacts, as described in the previous section, ranged between the 21.3 m/s to 24.4 m/s (70 ft/s to 80 ft/s).

Consequently, high resultant deceleration levels were observed during the crash even with the SAFER barrier in place, as shown in Figure 9.

FIGURE 9 Driver C Accident Data

Because of the extremely high severity of the impact event, no comparable crashes were available for analysis. However, the benefit provided by the SAFER barrier during the Driver C impact was still evident. Based on the severity of the impact, severe injury and/or fatality seemed the most likely outcome. However, Driver C walked away from the crash uninjured and was available to race on subsequent days. The lack of serious injury could be directly attributed to the performance of the SAFER barrier in combination with the driver restraint systems used in Driver C's race car. By impacting the SAFER barrier rather than the outer concrete wall, the severity of the impact was reduced by the barrier absorbing a significant portion of the impact energy, thus reducing the impact loads imparted to the driver and extending the duration of the impact event. This, in turn, provided a better opportunity for the driver restraint and car safety systems to protect him. Acceleration data taken from the impact event showed the duration of the impact pulse to be approximately 250 msec, as shown in Figure 9. Typical impact pulse lengths for this type of crash would be well under 100 msec.

It should also be noted that the SAFER barrier retained its integrity even under the extreme loading conditions of the Driver C impact event. Damage to the vehicle and barrier is shown in Figure 10. The SAFER barrier remained intact during the impact, and damage to the system consisted of crushed foam cartridges and a gouge formed in the bottom tube of the impact plate by the impacting vehicle. The gouge did not adversely affect the stability of the race car during the impact, and the deformation of the steel tube during the formation of the gouge likely provided some additional absorption of the vehicle's kinetic energy. This type of localized damage can be repaired quickly during caution laps by welding a steel patch plate over the damaged area.

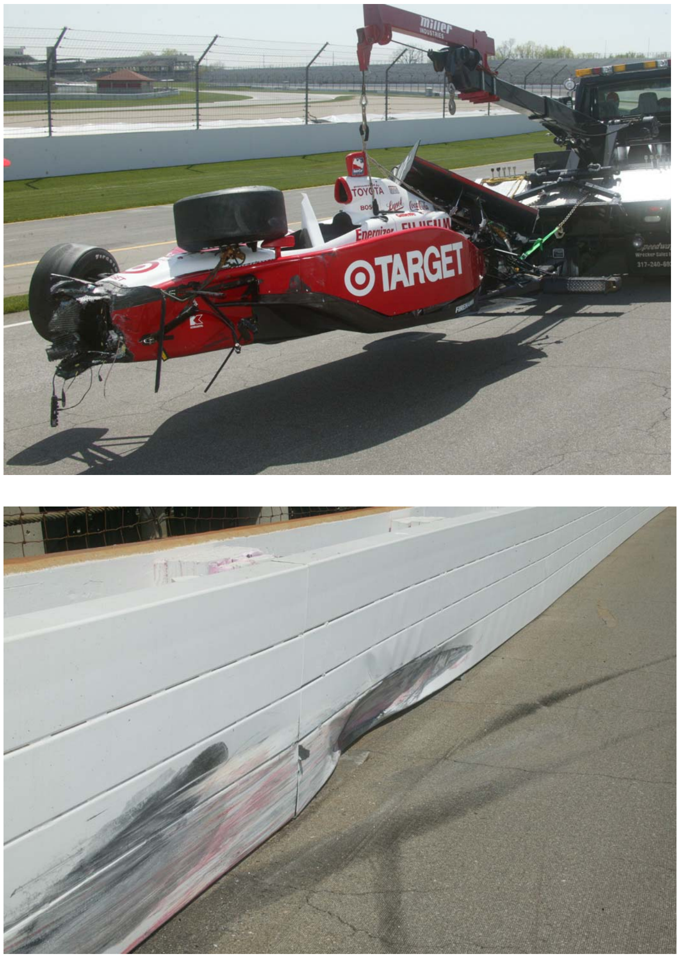

FIGURE 10 Driver C Accident Damage

NASCAR SAFER EVALUATION

Similar positive evidence of the safety performance of the SAFER barrier was observed with regards to impacts by NASCAR race cars. Data from both driver-side impacts and frontal oblique impacts were collected and analyzed in order to evaluate the performance of the barrier.

Driver-Side Impacts

Driver-side impacts are some of the most dangerous impacts in racing. Typically, these impacts involve a loss of control of the vehicle that causes the vehicle to impact the wall in a rear oblique or driver-side orientation, thus maximizing the impact loads on the driver. Several impacts of this type have occurred on tracks with and without the SAFER barrier installed. Three of the more severe impacts were chosen for comparison in order to demonstrate the performance of the SAFER barrier.

The first impact event involved Driver D losing control of his stock car vehicle and impacting on the outer concrete wall in turn 2 with the driver side of the car on a 1.21-km (3/4-mile) oval track. Impact conditions for Driver D's accident were a speed of 188 km/h (117 mph) and an angle of 16 degrees. This impact was compared to a pair of similar impacts on race tracks with the SAFER barrier installed. These impacts were designated the Driver E and Driver F crash events. Driver E lost control of his vehicle on a 4.0-km (2.5-mile) oval track and impacted the SAFER barrier with the driver side of the race car at an estimated speed of 185 km/h (115 mph). Driver F lost control of his vehicle on a 1.21-km (3/4-mile) oval track and impacted the SAFER barrier with the driver side of the race car at an speed of 129 km/h (80 mph) and an angle of 37 degrees.

Comparisons of the accelerometer data taken from these three impacts are shown in Figure 11. Analysis of the lateral change in velocity for these events demonstrated to researchers that the vehicles impacted the outer containment wall of their respective tracks with similar severity. Driver D, Driver E and Driver F displayed a lateral velocity change at 200 msec of 22.3 m/s (73.0 ft/s), 22.9 m/s (75.0 ft/s), and 20.6 m/s (67.5 ft/s), respectively. The similar magnitudes of the lateral change in velocity indicted that similar levels of kinetic energy were dissipated during the impact with the outer wall. Lateral change in velocity tends to be a reliable representation of the severity of the impact, and large changes in lateral velocity generally correspond to high impact velocity vectors into the outer containment wall. Therefore, the values observed in these three driver-side crashes were believed to represent similar impacts with a high degree of severity.

Examination of the acceleration data from each of the impacts displayed a much different behavior for the unprotected concrete wall impacts as compared to the impacts with the SAFER barrier, as shown in Figure 11. Driver D's impact resulted in a very high peak acceleration of over 100 g's during a crash pulse with a relatively short duration of approximately 25 msec. This type of high magnitude, short duration pulse was indicative of a very violent impact event, usually resulting in high impact loads being imparted to the driver and a likelihood of serious injuries. In contrast, the acceleration data showed that Driver E and Driver F experienced much lower peak resultant decelerations of 28.5 G's and 30.1 G's over much longer crash pulse durations of 175 msec and 160 msec, respectively. This demonstrated a dramatic reduction in peak deceleration levels of more than 70 percent for the impacts involving the SAFER barrier. Similarly, the duration of the crash pulse was increased almost seven times.

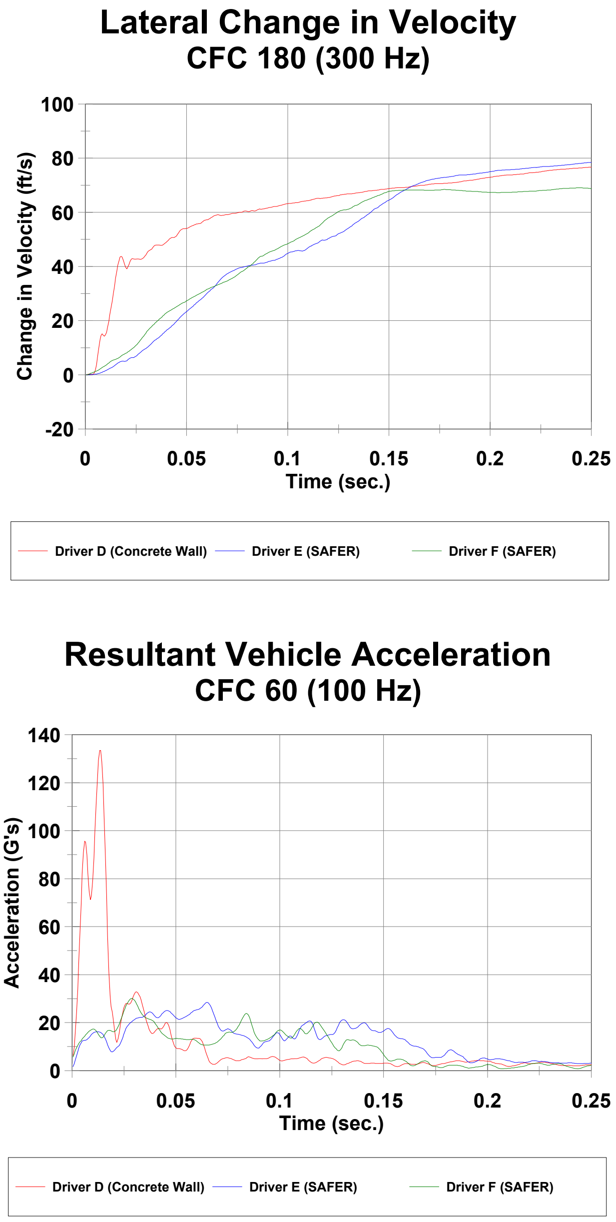

FIGURE 11 Driver-Side Accident Data Comparisons

The drastic reduction in impact loading and crash pulse duration would suggest that the drivers involved in the SAFER barrier impacts would have suffered a much less violent impact and their driver restraint safety systems would have been afforded a greater opportunity to protect the driver of the race car. This fact was reflected in the severity of the injuries sustained by the drivers in each the three impacts. Driver D sustained critical injuries, including trauma to the head and chest. Driver E and Driver F walked away from their respective impacts uninjured and were able to race in subsequent events.

Frontal, Oblique Impacts

A final comparison was made between a series of frontal, oblique impacts which occurred with stock cars. Impacts of this nature were similar to full-scale crash tests conducted during the development of the SAFER barrier. As a result, MwRSF researchers were interested in the comparison between impacts occurring into the concrete outer walls and the SAFER barrier installations under actual race conditions as well as with the results from the full-scale crash tests.

Two high severity, frontal, oblique impacts into concrete outer walls were chosen for the comparison. Driver G impacted on the outside of turn one on a 1.21-km (3/4-mile) oval track with the right front corner of his stock car. He suffered minor thoracic fractures and a fractured leg as a result of the accident. Driver H was involved in a similar crash on a 2.4-km (1.5-mile) tri-oval track where he impacted the outer concrete wall in between turns three and four with the right front corner of his stock car. Driver H suffered a concussion and minor thoracic fractures as a result of the accident.

For comparison purposes, the researchers first compared these impacts with the full-scale crash test results from test no. IRL-18. Crash test no. IRL-18 was conducted into the original version of the SAFER barrier installed at the Indianapolis Motor Speedway. The impact conditions for this test consisted of a 1,630-kg (3,594-lbs) stock car vehicle impacting the SAFER barrier at a speed of 196.4 km/h (122.0 mph) and an angle of 21.5 degrees. A comparison between the accelerometer data from these three impacts is shown in Figure 12. As mentioned previously, lateral change in velocity is a good measure of the severity of an impact. Similar lateral changes in velocity of 23.2 m/s (76.3 ft/s), 23.3 m/s (76.6 ft/s), and 25.3 m/s (83.1 ft/s) were measured for the Driver G, Driver H, and IRL-18 impacts, respectively. This suggested that the two impacts on the unprotected concrete wall had very similar impact energies, and the IRL-18 impact had a slightly higher impact severity. Examination of the resultant acceleration data from Figure 12 demonstrated the effectiveness of the SAFER barrier in these types of impacts. Driver G and Driver H experienced peak resultant decelerations of 75.7 G's and 76.0 G's, respectively. In addition, the crash pulse for these impacts was less than 100 msec, which limited the effectiveness of the driver restrain systems. In contrast, the IRL-18 impact displayed a less severe crash pulse with a peak resultant deceleration of 54.7 G's over the 150 msec event. These results represent an approximately 28 percent reduction in the severity of the impact due to the presence of the SAFER barrier. The reduction in impact severity is especially significant when one considers that the IRL-18 crash event had an approximately 8.5 percent increase in lateral velocity change compared to the concrete wall impacts.

This reduction in severity was also observed in the damage sustained by the vehicles, as shown in Figure 13. The top two photographs in Figure 13 show the damage sustained by the Driver G and Driver H vehicles during their impacts with the concrete wall. The bottom photograph shows the damage sustained by the vehicle in test no. IRL-18. Examination of the damage showed that the concrete wall impacts resulted in large deformations to the frame and occupant compartment on the right side of the vehicle, while the vehicle used in test no. IRL-18 displayed relatively small amounts of deformation. Reduced vehicle damage during SAFER barrier impacts has been observed by many track officials. The reduction in vehicle damage was an unanticipated benefit of the use of the SAFER barrier in that more cars are able to exit the track under their own power after accident, thus reducing the number of caution laps during the race.

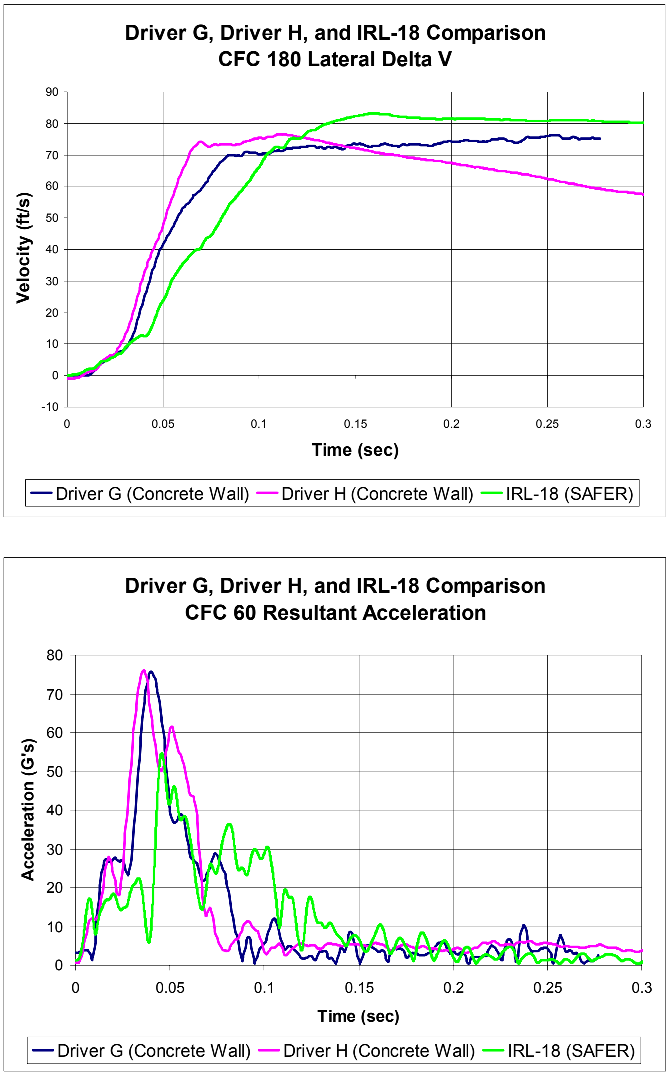

FIGURE 12 Driver G, Driver H, and IRL-18 Accident Data

Further comparisons of the two unprotected, concrete wall impacts were made with test no. IRL-22. Test no. IRL-22 involved a full-scale crash test into the current version of the SAFER barrier consisting of a 1,645-kg

FIGURE 13 Driver G, Driver H, and IRL-18 Vehicle Damage

(3626-lbs) stock car impacting the barrier at a speed of 215.5 km/h (133.9 mph) and an angle of 25.5 degrees. Comparison of the lateral change in velocity of these impacts, as shown in Figure 14, revealed that the IRL-22 impact had a 31 percent higher lateral velocity change of 30.6 m/s (100.4 ft/s). As mentioned previously, the higher lateral velocity change in test no. IRL-22 suggested a significantly more severe impact than that observed during the Driver G and Driver H impacts as well as the IRL-18 impact. However, comparison of the acceleration data, as shown in Figure 14, yielded a peak resultant deceleration of 53.4 G's and a crash pulse duration of approximately 150 msec. This represents an approximately 30 percent reduction in the severity of the impact due to the presence of the improved, curved version SAFER barrier. It was believed that the redesigned energy absorbers and the additional 203 mm (8 in.) of foam crush allowed the barrier to provide a similar reduction in severity to the IRL-18 impact event even though the lateral change in velocity was significantly higher.

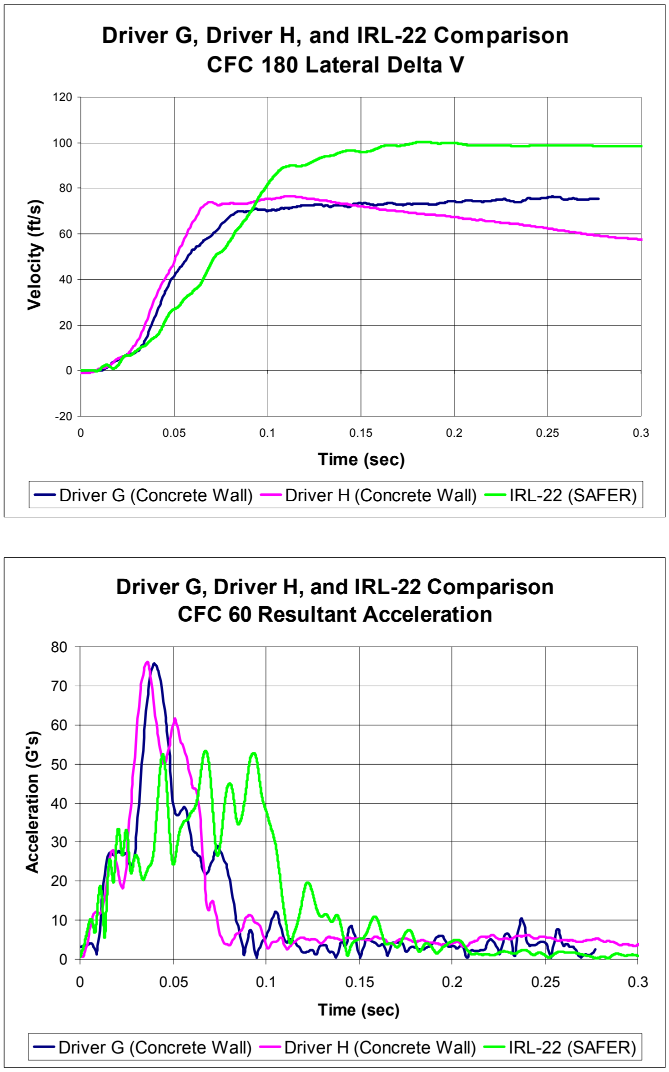

FIGURE 14 Driver G, Driver H, and IRL-22 Accident Data

A final comparison of frontal, oblique impacts was conducted using a real world impact on the current version of the SAFER barrier under race conditions. Driver I impacted the SAFER barrier on a 2.4-km (1.5-mile) oval track at a speed of 178.6 km/h (111.0 mph) and an angle of 20 degrees. Comparisons between the accelerometer data from the Driver I impact and the Driver G and Driver H impacts are shown in Figure 15.

Examination of the lateral change in velocity from these impacts showed a 26.67 m/s (87.5 ft/s) velocity change, thus indicating that the Driver I impact had a higher severity than the concrete wall impacts. The acceleration data from the Driver I crash event, as shown in Figure 15, demonstrated a third example of the improved safety performance of the SAFER barrier. The Driver I impact resulted in a peak resultant deceleration of 54.5 G's and a crash pulse duration of 140 msec. Again, the SAFER barrier resulted in a 28 percent reduction in the impact load and a significant increase in the crash pulse length. These benefits were translated directly to a reduced potential for driver injuries. Driver I sustained no injuries in the accident and walked away from the car under his own power.

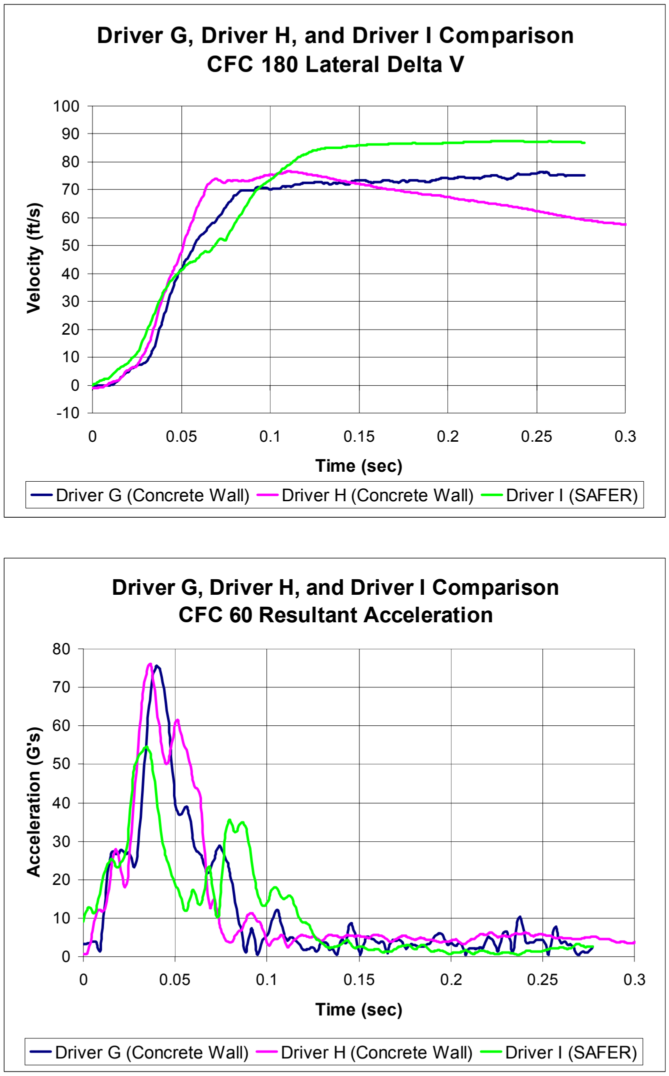

FIGURE 15 Driver G, Driver H, and Driver I Accident Data

CONCLUSION

The in-service performance evaluation of the SAFER barrier for high-speed race track applications yielded very positive results. A wide-range of race car accidents were investigated, including impacts with both IRL and NASCAR vehicles as well as crashes with varying impact conditions such as frontal oblique, rearward, and driver-side impacts. Comparisons were made between real-world accidents involving the SAFER barrier as well as unprotected concrete outer walls. Additional comparisons were made between the real-world data and full-scale crash tests conducted during the development of the barrier. Only the most severe accidents were chosen for the analysis because the more numerous, less severe impacts did not pose as high of a risk for driver injuries.

Results from these comparisons demonstrated that the SAFER barrier functioned very well in reducing the severity of critical accidents into the outer containment walls of the race track. For the majority of the SAFER barrier impacts, an approximately 30 percent reduction in peak deceleration levels was observed. For other impact conditions, decreases in peak deceleration as high as 80 percent were observed. The reduction in the impact loads imparted to the driver, when combined with the corresponding increase in the length of the crash pulse, provided a better opportunity for the driver restraint and vehicle safety systems to protect the driver from serious injury. This was evidenced by the lack of any serious driver injuries occurring with impacts into the SAFER barrier as compared to impacts into unprotected concrete walls.

The in-service performance evaluation of the SAFER barrier also identified several benefits not related directly to driver safety. First, accident experience with the SAFER barrier has shown that the barrier retains its integrity even under the worst-case impact scenarios. This means that little or no debris from the barrier is scattered to the track and long repair times are not required. Second, the most significant damage observed to date consisted of localized deformation and tearing of the tubes on the impact plate which can be quickly repaired using welded patch plates. Finally, race track officials have generally observed reduced race car damage on vehicles impacting the SAFER barrier as opposed to unprotected concrete walls. This reduced vehicle damage often allows the cars to exit the race track under their own power without having to be towed. These factors all combine to reduce race delays and caution time and provide a better quality race for viewers and racers alike.

Over the last three years, the SAFER barrier has proven to provide a significant improvement in motorsports safety for high-speed, oval track racing. The SAFER barrier, when combined with other advances in the driver safety restraint systems and improvements in vehicle design, will allow high-speed racing to continue with a much reduced propensity for serious driver injuries and/or fatalities occurring in vehicular crashes with the outer containment walls.

DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Indianapolis Motor Speedway, the Indy Racing League, nor NASCAR. This report does not constitute a standard, specification, or regulation.

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