FRA REGS ARE BASED ON BAD SCIENCE

HISTORY & PHYSICS BEHIND THE BUFF STRENGTH DEBATE

by Wayne S. Williams

On April 17, 1973, I handed in my final exam for my BSME at Pitt, got on a plane that afternoon from Pittsburgh to the Bay Area, and was on the SP payroll the next day. It was a dream job made possible by my junior year internship at the West Colton Yard construction project, working as a junior rodman for the amazing Godfrey Lyon, as a result of a phone call I placed directly to Harry Williamson, SP's Chief Engineer. I reported to work at the Mechanical Department, got a grey metal desk in a bullpen, surrounded by cheap yellow-paint walls, and I was in heaven, with the exception of the unofficial "no-pretty-women-on-the-payroll" rule. (D.J. Russell thought that would be distracting to us guys.)

Wally Greb was my boss, and William Thompson was his boss. Bill Thompson was the Chair of the prestigious AAR Car Construction Committee, and everybody else in the scarce One Market Street 3rd floor cubicles (Mechanical Department Managers) were on every other AAR committee you could think off: WABL, Coupler & Draft Gear, Open Top Loading, you name it. My boss (Wally) very reluctantly agreed to be on the important Tank Car committee, only if SP agreed to cover his potential lawsuits. I think Mr. Biaggini had to sign off on that one.

INSIDE AAR'S CAR COMMITTEE

At Pitt, I had years of access to the Westinghouse mainframe computer systems, so I came to SP as a fully loaded engineering computer geek. Bill and Wally assigned me to perform stress analyses and engineering calculations to support the AAR committee activities, where proposed new freight car design configurations were reviewed and approved before they were allowed into interchange service.

Bill was a class guy and a real railroad man, and he didn't warm up to cocky young up-starts, which is what I was. Somewhere in 1973, Bill got a submittal from American Car and Foundry (ACF) for a freight car design dubbed the "Glasshopper". Seems that ACF wanted to take fiberglass ICBM fuel tanks, attach a steel structure at each end, add trucks and whamo, instant hopper car. Bill gave me the stress analysis task, which was tricky because fiberglass material properties depends on which direction the fibers are imbedded and forces applied. At any rate, my report said this railcar would break in a certain place. Three weeks later, Bill advised me that the damn thing broke right where I said it would. My credibility went up with Bill.

After that, I was given an entire copy of the M-1001 AAR Design Manuals, which I absorbed like a sponge. Although many people in the industry had these manuals, and were familiar with the engineering calculations, my task was different. As Chair of the AAR Car Construction Committee, Bill frequently fielded proposed additions or modifications to the rules, and I was to analyze and make recommendations on these proposals. I had another advantage. The original author of the AAR freight car design criteria was Cedric Leriche, who held Bill Thomford's position at SP before he retired, and Mr. Leriche was a frequent visitor to One Market 3rd floor.

At the same time, I had also been appointed to the SP Track-Train Dynamics Team, headed up by Ed Lind after his return from running the joint FRA-AAR-RPI research program that addressed mechanical and operating problems that resulted from an industry change from 70 ton to 100 ton equipment. We had a bunch of new computer simulation tools, and the most important one was the Train Operations Simulator. Norm Luttrell from the Engineering Department wrote this program, and now applied it to solve the big derailment headaches at places like Tehachapi, the Cantera Loop, and Arkansas hogback territory. Norm simulated the worst possible train operations conditions, and we curiously noted that we rarely calculated a draft load in excess of 350,000 pounds. A buff load of 275,000 pounds was enough to derail a train either by jackknife or rail rollover. Even nasty train action run-ins and run-outs did not result in buff or draft loads anywhere near the AAR criteria.

So it was inevitable that I had to ask Mr. Leriche about the origin of the 1,000,000 pound buff force axial load requirement for freight car design. Cedric's answer was very simple: at 600,000 and 800,000 pound design loads, coupler yokes and draft gears kept getting yanked out, so the design load was increased until the failures stopped. That reminded me of the famous phrase used in freight car design, "steel is inversely proportional to brains", and Cedric acknowledged that was pretty much how we got to 1,000,000 pounds.

NASA had developed an entirely new computer based structural analysis process called finite element analysis, and the original program was called NASTRAN (NASA Structural Analysis). In 1976, I performed one of the very first computer based finite element design analyses in the railroad industry. Seems that one of Bill Thomford's personal design projects, the sliding center sill Hydra-Cushion™ boxcar in auto parts service was failing in the huge casting that held the fixed center sill and body bolster together. The analysis required 5,000 punch cards (computer geeks today have no idea what a pain in the neck punch card computing was in the 70's). The analysis showed that the freight car design was fine, but that vertical bouncing caused by poorly maintained panel track outside of Tonawanda NY on the emerging-from-bankruptcy Conrail system was the problem. The key to solving this mystery came from Bob Austill, who noticed that the spring coils in the trucks were deformed from bottoming out. Subsequent engineering analysis focused on vertical ride quality and vibration stability, and that solved the problem.

This was one of my first clues about why the AAR Design Manual is out of whack with the real world. In a nutshell, the structural design requirements have been continually ratcheted up over the years to compensate for a variety of instabilities in both train action forces (longitudinal) and freight car suspensions (vertical bounce and lateral "rock-and-roll"). It was exactly like Mr. Leriche said: if something broke, the structural requirements were increased until the problem went away. Even worse, rather than analyze the engineering problems with the appropriate (but more complex) dynamic analyses, the AAR Car Construction Committee decided to stick with static equivalent structural analysis.

Personally, I did not understand this decision, because it results in freight cars being much heavier than they need to be. Think of all the weight and fuel savings that the railroads could enjoy. Finally, I found out what the real problem was.

Advanced structural analysis (especially in aerospace, automotive and bridge applications) utilizes fatigue analysis that considers the full spectrum of load magnitudes and frequency. In another Track-Train Dynamics effort, the railroad industry actually tried to study the real world force spectrum to better understand and modernize design requirements. I was on a test train in 1976 where we had a new fabricated truck design strain-gauged, and we were recording forces and loads in all kinds of operating conditions. We were not seeing anything near the AAR design criteria.

DESIGN FOR NEEDLESS ABUSE

One night, our test train consist was stopped in the Pine Bluff (Arkansas) yard, and I was standing on the test car vestibule, when the cut of hopper cars next to me was heavily impacted by a cut of loaded boxcars that was just sent down from the hump. The impact was so hard that the hopper car body came off the trucks for a moment. Subsequently, we heard overspeed impacts all over the yard that sounded like bombs going off everywhere. We called the yardmaster to find out what was happening, and it turned out that some desk-pounding Operating Department big shot was mad because the receiving yard was all backed up, and he just finished chewing out the Yardmaster. So the Yardmaster just turned off the retarders and shoved everything over the hump. Watching these huge overspeed impacts turned on my light bulb regarding the problem with the AAR design criteria.

The 1,000,000 pound buff requirement is based on an abusive operating environment where railroad management and labor have been beating the living daylights out of the freight car equipment in switching and hump yard operations. Instead of controlling the operating environment, where incredible savings in weight and fuel can be realized, it is easier to beef up the equipment to accommodate a violent environment. And thanks to the FRA, the passenger car design requirements simply adopted some of the AAR numbers (especially the 1,000,000 pound axial load requirement) without consideration of the history and background of the engineering criteria.

As a member of the APTA Shared Use Right-of-Way Working Group, I shared these insights recently with FTA and FRA representatives. The entire passenger rail industry knows that FRA regulations are stifling competitiveness with other transportation modes, and are looking for realistic relief from excessive regulation. Current FRA decision makers were advised point blank that existing structural requirements have nothing to do with safety. Who cares if a passenger car survives an impact if all the riders are crushed against a bulkhead?

Using an analogy provided by a friend, this is like putting a mouse in a safe, throwing it off the Empire State Building, and congratulating yourself because the safe survived, even though the mouse didn't make it. Despite the overwhelming evidence of the inappropriateness of the 1,000,000 pound criteria (versus crash energy dissipation and safety performance criteria), the FRA stubbornly refuses to consider any alternative.

According to the History Channel, the auto industry caught on to the problem of excessive vehicle stiffness and the relationship to injuries when fighter pilots in World War II were experiencing more fatalities from off-duty car accidents that from combat activity. The results were seat-belts and crumple zone design evolutions. Thanks to the FRA, we in the passenger rail industry are forced to ride 1945 Packards.

Eric McCaughrin's article in the last CRN ("FRA: Keeping Rail Safe and Obsolete") was a shot in the bullseye. The FRA, for whatever reason, is the single most significant impediment to the future success of the passenger rail industry. It is my hope that revelations of the FRA's intransigence will cause rail advocacy groups across the nation to bind together in a strong effort to get the FRA pointed in the right direction.