The Hidden Costs in Product Life Cycle Cost Analysis

Product Life Cycle Cost Analysis, Cost of Ownership, LCA (Life Cost Analysis), Whole Life Cost, and "Cradle to Grave" Costing – what do these names and acronyms have in common? The answer is they all are used to define the calculation method that evaluates the cost of a product throughout its time in service. This is certainly nothing new to the rail industry. In fact, many governments and municipalities require an LCA as part of a tender offering; and some transit authorities have expanded the criteria to include end-of-life costing and the triple bottom line[1] of the cost impact upon environmental sustainability. Surprisingly, LCA is oftentimes misunderstood or only partially considered in railway tender awards.

In defense of the transit authorities [and from their perspective], many vendors enhance or misrepresent their respective products' life performance claims and either omit substantiated time-simulated data or exaggerate future savings. Typical cost models have the tendency to be over-simplified and lack the flexibility needed to accommodate specific and customized variables not shared among transit authorities. Lastly, there are hidden, intangible and questionable costs that may be difficult or impossible to estimate.

Seating Life Cycle Analysis

While life cost analysis can be assessed for any rail car component, seating tenders offer the best opportunity to scrutinize the validity of an LCA model. Within the interior, seating is one of the five most costly elements of the rail car and is at the top of the list for future refurbishments. Assessing new build costs with forecast refurbishment estimates is seemingly straightforward. As a start, a Whole Cost Analysis would include the following factors: (1) the cost of seating for the initial new-build delivery (2) assumptions of how far into the future the

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[1] Triple bottom line (TBL, 3BL) in accounting terms references the means of expanding the traditional reporting framework to take into account ecological and social performance in addition to financial performance

transit authority will keep the seats in service before a full or partial refurbishment (3) estimated costs of the refurbishment and (4) historical costs for replacements between refurbishments. Other considerations may include the cost of labor and lost revenue while the seat or rail car is in refurbishment or out of service. Rider ship dissatisfaction due to seating discomfort or style could also be identified as an intangible cost. But, regardless of the depth of such an analysis, this list is relatively common and generally used in the decision matrix. There are, however, hidden costs that rarely come to the surface.

Hidden Costs

In the development of a seating life cycle cost analysis, Time-to-Refurbishment is most commonly coupled to Loss-of-Comfort. An argument can be made, however, suggesting Compromised Safety as another criterion, which could become a significant source of hidden cost. The notion of Compromised Safety is predicated upon the global rail standards that address flame, smoke, and toxicity (FST), such as ASTM D 3675, BS 6853, NFF 16-101, and DIN 5510. Full seat assemblies or the individual materials in the construction of a seat and seat cushion are mandated to conform to specific FST measurements dependent upon the category of the train. In practice, certified third-party FST test reports must accompany a seating tender as verification of conformance. Thus, the qualification testing of a material or full seat is of the utmost importance. Conversely, there are significant consequences if the test report comes back as a NO PASS or at a rating lower than intended.

The language in the standards, as well as the testing methods, is the result of professional expertise and years of collaboration. They are well-defined, sophisticated and strictly reviewed. Thus, the preparation of a vendor sample designated for testing submission will be of the highest level of engineering and craftsmanship. For example, a seat, which is to be submitted for a British Spec (BS) 6853 Category 1a burn test, will be meticulously assembled, with special attention to the wrapping of the fire barriers and upholstery fabric over the foam seat cushion. The tighter the fit of the upholstery folds and tucks, the lower the risk of air paths between the fabric and foam cushion. An air path has the potential of becoming an oxygen source for accelerated flame spread. Objectively, the entire process is logical, legitimate, and of the utmost regard for the safety of the ridership.

Why, then, is this a discussion on hidden life cycle costs? The answer to this question is built upon cycle-testing data, field observations, and a hypothesis.

It has been established that achieving good FST results is partially dependent upon the best-of-the-best material samples and assembly practices. What would be the FST results if a mass-production seat were pulled out of service after thousands of cycles and months or years of usage? Depending on the type of foam specified for the cushioning, the cycling of a seat can result in a loss in foam thickness, reduced spring-back force[2], and compromised weight distribution, which directly affects comfort performance. This deterioration will cause the fit between the upholstered fabric, fire barriers, and foam to become loose and crumpled.

In a recent lab study performed in the UK, a 100,000 cycle test was conducted on two upholstered foam cushions: fire-retardant open cell polyurethane foam and open cell silicone foam. The empirical data is astounding. The fire retardant polyurethane material diminished in thickness by >10% with a spring force loss of >50%, while the silicone foam deterioration was negligible in both thickness and spring force. In addition, the polyurethane cushion took on a compression set with a concave shape replicating the shape of the Jounce and Squirm impact apparatus. The discoloration, as seen in the photo, is the remnants of the fire retardant filler after having eroded away the cell walls of the polyurethane foam. (See Figure 1). In complete contrast, the silicone foam shows no shaped

[2] Spring back force is defined as the resultant force the foam will have upon the load of the passenger, which is directly related to comfort.

compression set and has no visual defects. While this is test data, it has been observed in the field as well. The photo of the cycle tested upholstered polyurethane cushion is comparable to worn and loose seats found in service. (See Figure 2).

Back to LCA!

Would this 100,000 cycle tested seat still pass the FST requirements as did its hand-crafted predecessor without any cycling or wear? Is this a compromise of safety? Also, is this a hidden cost that should be included into an LCA? None of these questions is to be answered in this discussion, but only offered up as a question for serious thought. Comprehensively, a thorough life cycle cost analysis should include a systems approach – analyzing potential costs, with probabilities, of a system or module failure due to performance degradation of the component under evaluation.

In the case of the seats, there may be a point in time when loss of thickness, spring back force, or a shaping from compression set could cause a system failure. The system failure could range from acceptable comfort to something as severe as non-compliance to an FST standard.

Rogers Corporation, the manufacturer of BISCO MF1 open cell silicone foam specially formulated for rail car seating cushions, will launch the **Seat Cushion Cost of Ownership Tool** (See Figure 3) at the upcoming Railway Interiors Show in Cologne. The tool allows the user to simulate a specific scenario: size of seat cushion, number of seats per car, number of cars in the fleet, average number of years between refurbishments, cost of competitive materials, labor rates, estimated number of replacements, need for fire barriers, and revenue loss. The calculator presents a picture of the total cost of ownership for each material along with metric tons of material that will be designated for landfill over the time period.

It will be up to the user to add in the hidden costs – if there are any – as suggested in this discussion. Hidden costs can be difficult to measure, but that doesn't make them any less significant, especially when it comes to any potential compromise of safety.

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