INTERNATIONAL ASSOCIATION OF
IABSC
BAGGAGE SYSTEM COMPANIES

IMPROVING BAGGAGE HANDLING SYSTEMS' HUMAN-MACHINE INTERFACE THROUGH DESIGN

White Paper: Recommendations to increase Baggage Systems' availability and ROI while improving Safety

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GLOSSARY

BHS	Baggage Handling System
AC	Alternating Current
ANSI	American National Standards Institute
CBRA	Checked Baggage Resolution Area
CE	European-Union
CEMA	Conveyor Equipment Manufacturers Association
CFR	Code of Federal Regulations
CS	Control Station
cUL	Canadian UL
DC	Direct Current
DHHS	Department of Health and Human Services
EDS	Explosive Detection System
EU	European Union
FDA	Food and Drug Administration
HMI	Human Machine Interface
HSD	High Speed Diverters
HSU	Horizontal Sortation Unit
IABSC	International Association of Baggage Systems Companies
IEC	International Electro-technical Commission
ISD	In-line Screening Device
ISO	International Standards Organization
MCP	Motor Control Panel
MHIA	Material Handling Industry of America
MTBF	Mean Time Between Failures
MTTR	Mean Time to Repair
NEC	National Electrical Code
NFPA	National Fire and Protection Association
NIST	National Institute of Standards and Technology
O&M	Operations and Maintenance
OSHA	U.S. Occupational Safety & Health Administration
PAC	Programmable Automation Controller
PL	Performance Level
PLC	Programmable Logic Controller
PMMI	Packaging Machinery Manufacturers Institute
REACH	Registration, Evaluation, and Authorization of Chemicals
RFID	Radio Frequency Identification
RIA	Robotics Industries Association
RoHS	Restriction of Hazardous Substances
SEMI	Semiconductor Equipment and Materials International
SIL	Safety Integrity Level
SRP/CS	Safety-Related Parts of Control Systems
TSA	Transportation Security Administration
TÜV	Technischer Überwachungsverein
UL	Underwriters Laboratories
USC	United States Code
VAC	Volts alternating current
VSU	Vertical Sortation Device

INTRODUCTION

Baggage Handling Systems (BHSs) have evolved over the years from simple point-to-point conveying systems that transport baggage from ticket counters to bag rooms into very complicated systems involving bar code and/or RFID scanning, Inline Screening Devices (ISD) and sortation to multiple destinations. These complex conveying systems with their specialized baggage handling equipment can actually result in reduced efficiency and safety. The reality is that at a number of airports, the operation and maintenance providers have to use inefficient and potentially hazardous activities in pursuit of their responsibilities due to design and/or installation failings.

Since it is not unusual for budgets to be stretched during major projects, it's easy to understand how customers can be tempted by the removal of "perceived non-essential" options in the pursuit of budget management. This ultimately leads to subjective design changes yielding to downstream problems associated with fewer maintainability and safety features in new installations. Unfortunately, due to the lack of complete knowledge and understanding of applicable safety standards and regulations (e.g. OSHA), combined with budget pressures, these "value engineering" actions can lead to mountains of inefficiencies, risk for worker safety, and corporate liability. Airports and Airlines are being provided a product that is inferior to what is available in terms of: Performance, Maintainability, and Safety.

This paper provides recommendations related to how efficient and proactive operation and maintenance activities can be successfully supported through relatively simple and often inexpensive BHS design and install considerations, with the added benefit of improved safety. In this white paper we will identify deficiencies of baggage handling systems and offer suggestions for improvement.

AUTOMATION IN BAGGAGE HANDLING SYSTEMS

Baggage Handling Systems are made up of conveyor as well as automated machinery. These systems could consist of Belt Conveyors (straight and curves), Queues, Merges, High Speed Diverters (HSDs), Vertical Sortation Units (VSUs), Tilt-Tray Sorters, Tote/Tray Systems, ICSs (Individual Carrier Systems), Baggage Carousels and other specialized baggage handling equipment and software. To ensure optimal availability (up-time), easy access and egress to/from each one of the components for troubleshooting, maintenance, and repair has to be guaranteed. This equipment, without proper physical guarding and safety monitoring could be potentially hazardous to maintenance and baggage handling personnel. Manufacturers, designers, and system integrators must ensure that each component of a baggage system and the system as a whole have appropriate safety features (e.g. guarding) and protocols. All system designers must realize that ensuring proper access to any component yields a higher system up-time and efficiency while improving its safety.

Safety guarding of equipment is well defined by OSHA, ANSI, ISO, IEC, PMMI as well as material handling industry associations, including: CEMA and MHIA. Safety of control systems, are also well defined by ANSI, PMMI, ISO, IEC and the Robotics Industries Association and other trade association standards development organizations. In addition, IABSC's White

Paper on Risk Assessment provides guidance to identify risks and determine actions to minimize or eliminate them.

DESIGN SHORTCOMINGS

When considering the potential root causes associated with BHS design short comings we must first understand why decisions are made that have an adverse effect on the overall efficiency and ergonomics of the system.

1. Manufacturers and systems integrators are driven, by contracting models, to deliver lowest acquisition cost, not lowest Total Cost of Ownership (TCO)
2. Many systems are viewed as "temporary", even though the intended design life is several years
3. Performance testing is mostly limited to security and throughput specifications and does not include up-time, maintainability and safe access and egress for maintenance and operations staff
4. Government entities are not inspected for compliance with the OSHA regulations and may not feel the same pressures to meet the full intent of the requirements
5. Airports and Airlines lack depth of system expertise and knowledge to challenge design and maintainability issues from development stage to punch out and system acceptance

MAIN FACTORS AFFECTING SYSTEMS' OPERATIONS

Since 2002, the baggage handling industry has worked in cooperation with the DHS's TSA to provide high quality solutions for the security risks inherent in transferring outbound luggage onto airplanes. Often times system operations, maintainability and personnel safety are compromised in the efforts to meet security challenges. Designers prioritize the TSA safety regulations over the systems ultimate performance, and intended purpose. This negatively affects the O&M providers and end users.

Several factors influence the system operating rates and overall productivity:

1. **Reliability** – the probability of zero failures over a defined time interval, driven by the right technology and its MTBF
2. **Availability** – the percentage of time a system is considered ready to use when tasked
3. **Maintainability** – measures the ease and rapidity with which a system can be restored to operational status following a failure; when it fails, how timely are the repairs (MTTR)?

Quite often, some of these attributes are "value engineered" out of the design in the interest of cost reduction as they are viewed as "non-essential" to the function.

Post install, airports and airlines use system availability as a key performance indicator. Total bag throughput, and percentage of bags securely, timely and accurately delivered to their destination are other key performance indicators that indicate a systems designed capacity. Operations and maintenance contractors are held accountable for the system and equipment "uptime". However, the accountability for system availability should begin at the design stage.

As an example, a Test provides the verification that the system meets the TSA's system requirements for security and overall throughput, but how are the airports' needs and requirements for sustainability being tested and verified? Short tests, sometimes 15 minutes, are performed with fairly uniform baggage in an almost "sterile" environment. Testing in almost perfect operational scenarios doesn't reflect the true stress a system is put under during peak demand. Additionally, system failure recovery testing is overlooked entirely.

Inability to meet required system throughput has resulted in the addition of more operational labor to make up for design flaws. Bio Diverter labor (Bag Straighteners) have become the industry's solution to these issues. For example, Bio Diverters are necessary at the entrances to narrow equipment, i.e. ISD machines and locations in the system that repeatedly jam. Technological solutions such as self-centering belts and angled rollers are often disregarded as more costly than the perceived low cost labor of Bio Diverter personnel. In reality, over the life of the system the bio-diverter labor solution is far from cost effective. This position typically has a high turn-over rate, which in addition to close proximity of operational equipment can result in the increased occurrence of work related injuries.

The below example outlines the costs of bio diverter personnel. These cost burdens are ultimately passed down to the customer.

Annual Cost of Bio-Diversion		
Scenario: EDS Matrix of four (4) L3 machines		
Two (2) low-skilled workers; (1 for every 2 machines)	2	Headcount
Operational coverage: 20 hrs / day 7 days / week, every week	7,300	Hours
Fully burdened labort cost per hour	$ 20.00	Rate
Estimated Cost Per Year	**$ 292,000.00**	

Although the labor liability for the use of Bio Diverter personnel traditionally falls under the responsibility of the maintenance contractor, OSHA's requirements for injury and fatality reporting now subject the airport to that risk as well.

How can we improve Performance, Maintainability, and Safety?

We propose three focus areas to improve the system design to benefit the future operation, efficiency, and safe working environment associated with BHS human-machine interaction.

1. System Maintainability
2. System Performance
3. System Safety

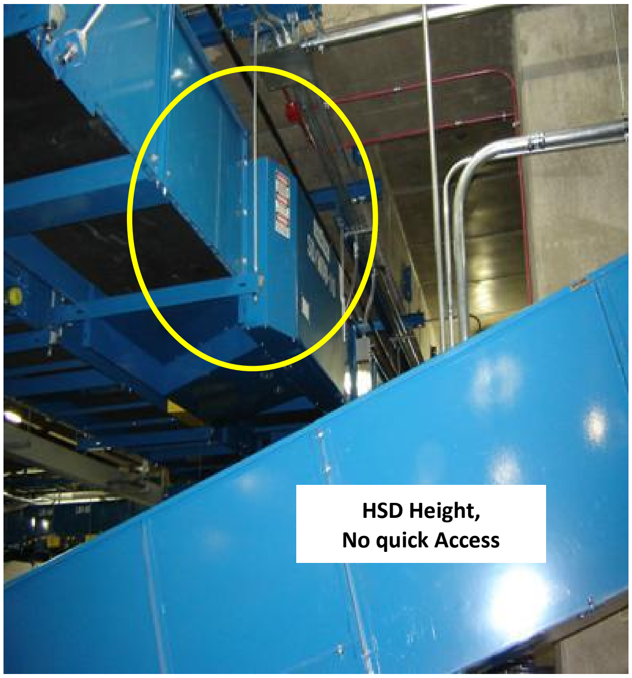
1. System Maintainability

1.1 Proper and clear access to ALL components of the system

As previously proposed, design flaws caused by a lack of understanding of OSHA safety regulations in addition to budget constraints result in inefficient and potentially hazardous baggage handling systems.

Making all sections of the system accessible to the maintenance technicians is a key element to ensure the timeliness of the repair and return of the system to operational availability. For example, there are instances where a complete section of conveyor must be pulled away from a wall to permit the replacement of a single bearing. 3D modeling is great tool to determine during the design stage where space conflicts could occur.

The following pictures show some of the challenges we face today.


HSD Height,
No quick Access


Power-turn
proximity to wall


Conveyor proximity
to wall

In addition to access and component/system's design (MTBF, MTTR), there are other aspects that contribute to the maintainability and up-time of a system for which the maintenance contractor typically has a significant level of influence over:

1. Technician skill and availability
2. Accessibility to spare parts
3. Time required to respond to location of failure

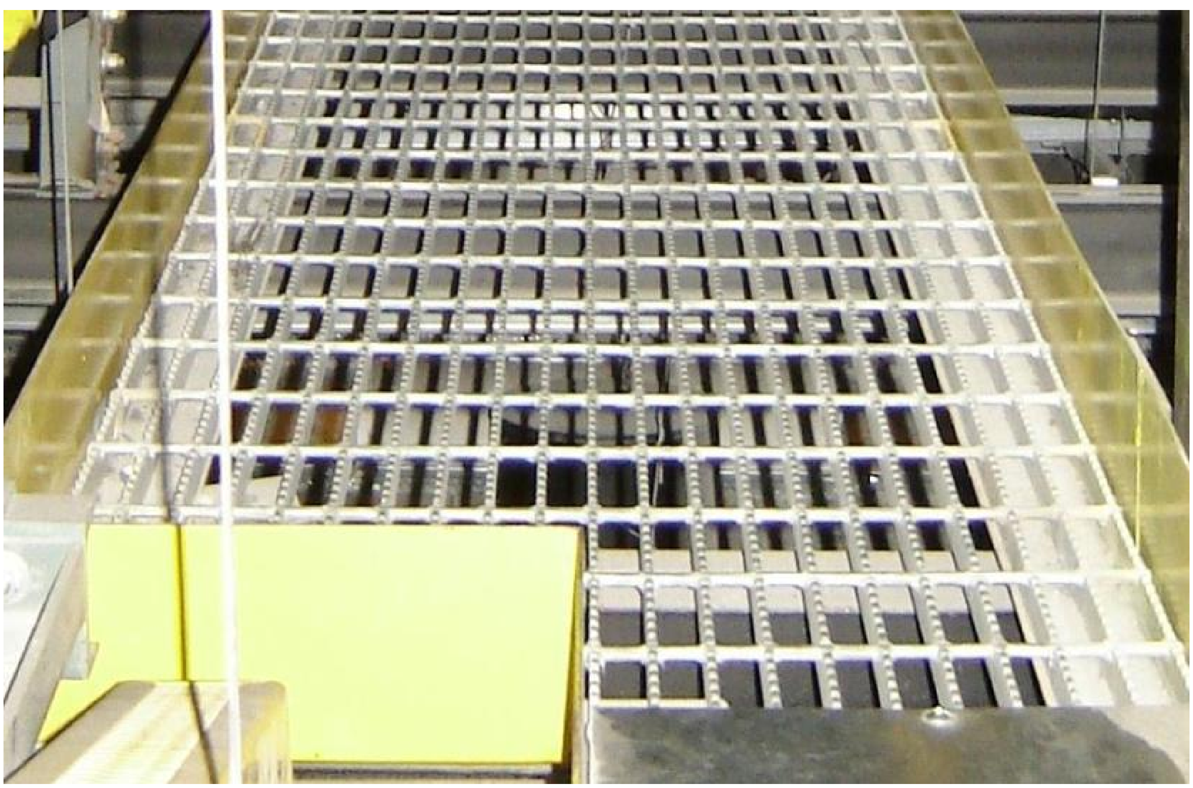
1.2 Maintenance Platforms (Catwalk)

Two types of Maintenance Platforms that are typically in use are *sheet metal pan style* and metal *grating style*.

Sheet metal pan is less expensive and is preferred by technicians because it is more comfortable for kneeling and has no gaps for parts or tools to fall through. Conversely, grated metal platforms while being more expensive are preferable from a safety and maintenance standpoint.

There is a good opportunity for compromise to only consider those areas where maintenance activities are to be performed and to use grated flooring for walking/access areas.

Solid Metal Maintenance Platform



Grated Metal Maintenance Platform

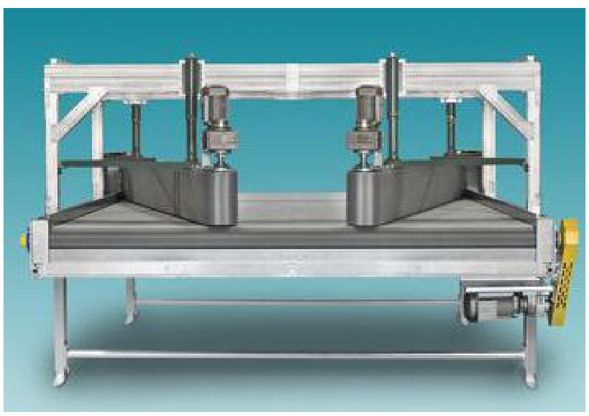
Working platforms for accessing vital areas of the conveyor system should be considered in the system design; lack of the necessary working platforms causes undue risk taking and increases injury to maintenance personnel.

In addition to sufficient Maintenance Platforms to support elevated systems, thought should also be given to the available ladder accesses to the Maintenance Platforms. Ideal ladder spacing would be 1 ladder for every 25 feet of conveyor. Easy ladder access to the Maintenance Platform areas will improve repair response times.

1.3 Single Points of Failure

The desire to design creative and sophisticated solutions to baggage flow that provide price and technological advantages can result in considerable downstream challenges. The ability to achieve uptime requirements is diminished once the system is operational and operating with peak demand volumes. Although it is appreciated that these designs may represent the only realistic solution, simplicity also has its value. A simplistic approach can significantly reduce the impact on systems availability by improving both repair time and contingency.

Complex design features include such things as Multi and Mega-Merges, 180 degree and also odd degree turns (i.e. 86˚). Typically these kinds of equipment provide reasonably high reliability however they can also represent a single point of failure. The complexity of these parts can result in extended repair times and the need to inventory or purchase specialized replacement parts. As a consequence of the introduction of this equipment, there is often no contingency within the system layout so when a failure occurs the repair becomes critical in order to restore the system to full operation.



2. System Performance

Ease of maintenance through optimal system access ensures that the system downtime is reduced, which leads to a higher throughput. It is more likely that the maintenance contractor fulfills the requirements for preventive maintenance when the system access is optimal, which in the end leads to higher throughput and better tracking throughout the system resulting in more accurate sorting to the allocated destinations.

A poorly maintained system typically has a decreased tracking and throughput performance, which has a direct impact on the systems operational performance. Any bags that are not successfully scanned, tracked through the system and cleared by EDS have a higher risk of being delivered to the aircraft late or too late.

3. System Safety

3.1 Machine Guarding

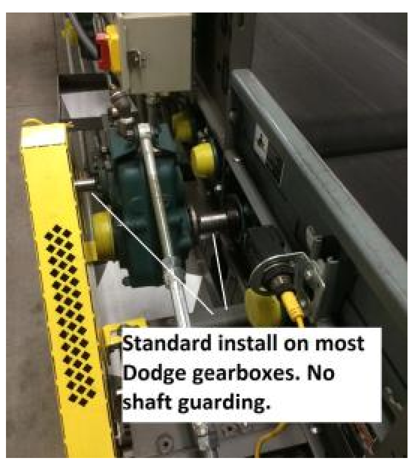
Despite a relatively high confidence in standard compliance (refer to OSHA Guidelines 1910.212(a)(1) and 1910.212(a)(2)) and baggage handling system safety, OSHA officers and safety professionals continue to find deficiencies during system inspections. While the majority of employers have good intentions for the safety of their employees, there still exists a gap in compliance. These gaps allow for worker injury and resulting corporate liability. While it is certainly easy to point out obvious deficiencies in guarding such as missing or inoperable guards, it takes much more effort to identify the true causes for these conditions.

Historical data on penalties, fines and injury statistics clearly show that machine-guarding hazards remain a high risk in baggage handling systems and throughout the general industry. In some cases, this data proves that the risk of injury from unguarded machines has been steadily increasing. For example:

- During FY2013, there were more than $7 million in proposed penalties for violations to machine guarding, whereas in FY2010 the same type of violations reached $6 million.

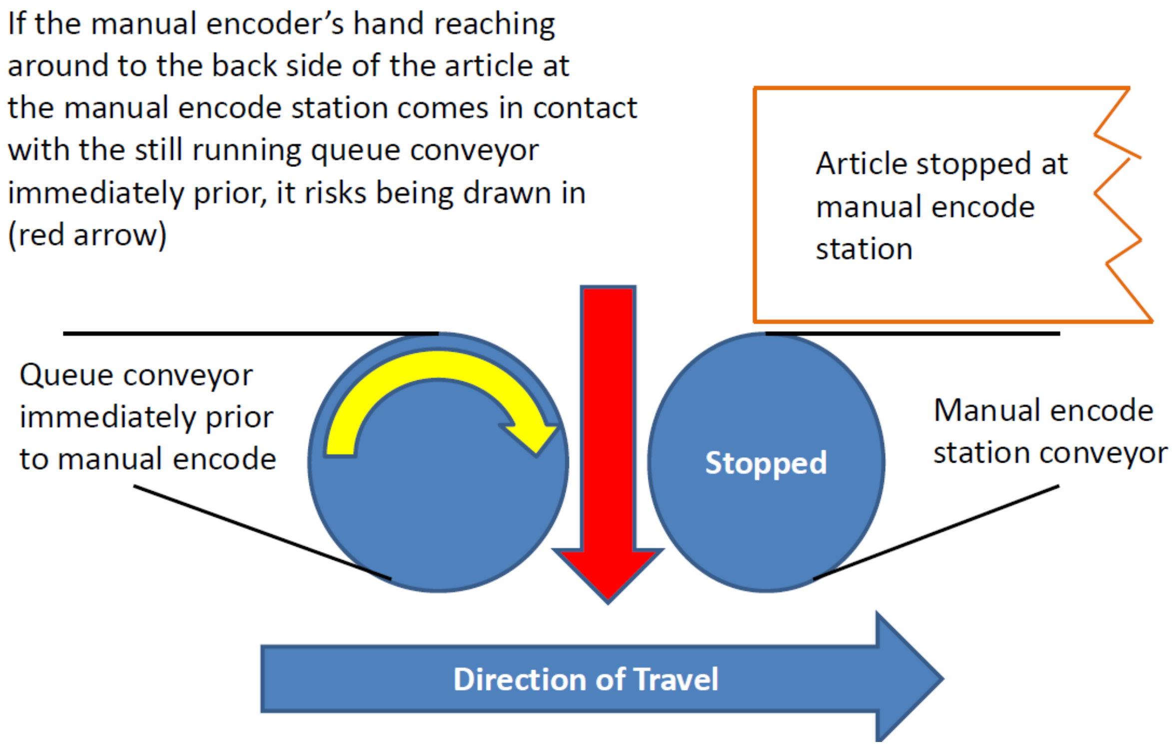
Following are the main contributors to machine hazards:

- Exposed/unguarded pulleys
- Exposed/unguarded sprockets, shafts, or rollers
- Unguarded conveyor/rollers over walkways, roadways or workstations that are lower than 8 feet



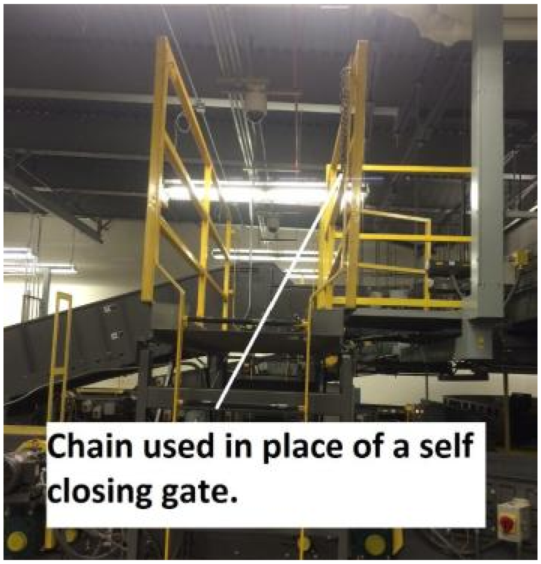
3.2 Manual Encode (ME) Station Conveyor

The manual encode station is another example of design function taking precedence over the safety needs of a worker interacting closely with moving conveyor. As it can be seen in the image below real danger exists with encoder personnel's proximity to belting during their regular activities. The role is repetitive and not mentally taxing, which opens the possibility to considerable personal injury exposure due to the loss of concentration and yes "short-cuts". One solution to this issue would be a simple change to the PLC to prevent the queue belt running when the following ME station section of conveyor is stopped. Another option could be an increase in the length of the ME Station conveyor from the queue belt so that the manual encoder is further away from active conveyor.



3.3 Maintenance Platforms Gating

When choosing between a loose link chain and a self-closing gate to protect opening in Maintenance Platforms, the seemingly obvious choice would be the self-closing gate. Chains can be installed improperly with too much slack, allowing them to move when leaned against and they require personnel to manually close. Given this, chains still prevail as guarding on cat walk openings. Cost is likely the reason this choice continues to be made. Self-closing gates are strongly recommended over chains to prevent falls.

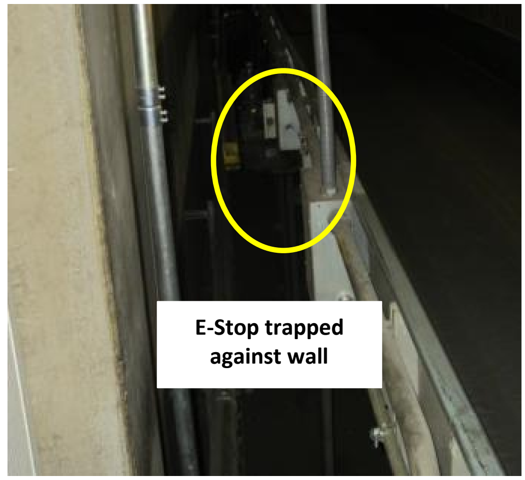


3.4 System Stop

OSHA requires to "Install clearly marked, unobstructed emergency stop buttons or pull cords within easy reach of employees."

From observations in the field, its clear many systems do not follow this OSHA requirement. Often the control/E-stop is being located on the side of the conveyor that is moving baggage, resulting in an obstructed path to the e-stop station. This improper access results in a delayed response time and numerous documented injuries. Injuries resulting from e-stop location or access issues (struck by object, contusions, fractures and lacerations of appendages) generate direct costs cost in the range of $1k - $113K per incident.

An example of this was an airline ticket-counter employee was struck by baggage while attempting to hit an e-stop when they attempted to jump over a running conveyor; more examples of wrong location are shown in the following pictures:



Other Safety concerns for design consideration:

3.5 Ladder Safety

Stepping on conveyor to access ladders, improper ladder clearances from adjacent equipment, improper overhead clearance at entry point, lack of caging at regulated heights and Maintenance Platforms ladders which are not well planned for proper clearance out of vehicle traffic, i.e. the ladder flips down in an aisle or between baggage carts all pose potential safety risks.

3.6 Accessible electrical (for Fans, Evaporative Coolers, Monitors, etc.)

Airlines Employees often utilize electronics and/or cooling apparatus (fans, coolers, etc.) at the baggage carousel. Properly placed electric outlets that allow for employee access without crossing/entering the baggage system will prevent exposure to exposed machine guard hazards rotating shafts, rollers and moving mechanism.

Personnel should not have to access the back side of the carousel to get tubs or plug in fans.

3.7 Falling object hazards from overhead conveyors and baggage debris

Overhead belt and conveyor systems that pass over a walkway, roadway, or workstation, should incorporate spill guards, pan guards, or equivalent to prevent materials from falling and striking someone below.

3.8 Emergency Egress

When a belt/conveyor system is installed above exit passageways, aisles, or corridors, a clearance of at least 6 ft. 8 in., measured from the walking surface to the lowest part of the conveyor/guards, should be provided.

If proper system operation would be jeopardized by the 6 ft. 8 in. requirement at an emergency exit, additional passageways for egress must be provided.

Passage through areas with belts/conveyors under 6 ft. 8 in. should only be permitted if the door is not designated as an emergency exit and a suitable warning is in place for low headroom.

3.9 End User Ergonomic Design

Once the baggage system is installed and operational, personnel will work at this equipment in an operational setting until it is modified or replaced. Designing the equipment to current ergonomic standards, for example carousel/pier height and personnel reach, are critical to support personnel health. Airlines for America (A4A) has documented current best practices that address equipment height and protection recommendations in the SG 901 Facility Planning Guidelines – New Baggage Handling Systems for Passenger Terminals.

SAFETY STANDARDS

4. BHS Specifications

Specifications developed by architects, engineers and consultants for the design and installation of baggage handling systems at the nation's airports nearly all reference and include U.S. standards and regulations developed by: OSHA, ANSI. And, in many respects, the BHS systems that are provided, comply with the majority of the requirements specified by the referenced standards. A properly designed system should meet supportability, maintainability and safety standards as recommended in this paper while maximizing efficiency, customer service and cost effectiveness. Safety should be considered in conjunction with other security parameters during the planning and design phase.

Some of the standards development organizations contributing to machine safety in the United States include: the American National Standards Institute (ANSI), the National Fire and Protection Association (NFPA), the U.S. Occupational Safety & Health Administration (OSHA), the Conveyor Equipment Manufacturers Association (CEMA), the Material Handling Industry of America (MHIA), the Organization for Packaging and Processing Technology (PMMI), and the Robotics Industries Association (RIA). In many cases these organizations cooperate and harmonize with one another.

5. OSHA General Duty Clause

5.1 SEC. 5. Duties

(a) Each employer – (1) shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to its employees.

New OSHA requirements (Reporting, Volume Expectation) will change the current rule requiring employers to report workplace fatalities and hospitalization of three or more employees to the new requirement (1/1/15) that mandates OSHA notification for each employee work-related hospitalization, amputation, or loss of an eye. OSHA expects its notification burden under the new rules to rise from **4,600 to 210,000** notices per year. In the past, notification of a fatality or multiple hospitalizations guaranteed a response and usually a visit from an OSHA investigator.

OSHA allows for states to have programs that have at least the same levels of regulation and oversight as OSHA.

> *The State shall promulgate a State standard adopting such new Federal standard, or more stringent amendment to an existing Federal standard, or an at least as effective equivalent thereof, within six months of the date of promulgation of the new Federal standard or more stringent amendment.*

26 states have their own OSHA agencies: MIOSHA Cal/OSHA, WISHA.

Illinois, New York and New Jersey are Public only.

With the likelihood of injuries to staff working around the BHS that are caused by design and installation shortfalls it will bring the BHS environment into the spotlight that may result in;

1. More Frequent Inspections
2. More Citations for Remedial Actions
3. More Attention from the Public (via News Media)
4. More Worker's Compensation related costs
5. More Civil Lawsuits and Lingering Black eyes for Consultants, A&E, OEMs

5.2 OSHA Guidelines

1910.212(a)(1)

<u>Types of guarding</u>. One or more methods of machine guarding shall be provided to protect the operator and other employees in the machine area from hazards such as those created by point of operation, ingoing nip points, **rotating parts**, flying chips and sparks. Examples of guarding methods are-barrier guards, two-hand tripping devices, electronic safety devices, etc.

1910.212(a)(2)

<u>General requirements for machine guards</u>. Guards shall be affixed to the machine where possible and secured elsewhere if for any reason attachment to the machine is not possible. The guard shall be such that it does not offer an accident hazard in itself of a baggage handling system most likely to have a machine guarding related injury.

SUMMARY

The U.S. Baggage Handling Industry has been somewhat slow to evolve and embrace designs that ensure high system's availability and efficiency while increasing the safety of the people that come in contact with them as compared to some of the other industries that utilize automated machinery and conveyors. While it is incumbent upon architects, engineers, consultants, manufacturers and systems integrators to provide an efficient and safe BHS, the ultimate responsibility, by law, for the proper and safe installation and operation of the BHS, lies with the BHS owner. Calling out the General Duty Clause, Section 29 USC 654 5(a)(1) of the Occupational Safety and Health Act – "*Each employer -- shall furnish to each of his employees employment and a place of employment, which are* ***free from recognized hazards*** *that are causing or likely to cause death or serious physical harm to his employees*".

The challenge is to make BHS more functional and efficient through the adoption and adherence of current U.S. and International standards while at the same time improving the safety of the system, without major cost increases when considering total cost of ownership.

Perhaps it is time that we rethink the way we implement design and install airport baggage handling systems.

Reasons to affect change today:

1. OSHA and State agencies will hold contractors and system owners to higher SAFETY standards via greater, more intrusive reporting
2. TSA Recapitalizations *WILL* end; Longer lives of systems will expose flaws and cost drivers
3. Growing Intensity and Reliance by Airlines on an Airport's BHS to be near perfect
4. Checked bag fee revenues and late bag costs have increasing leverage on airlines profitability

Top 10 Recommendations for Future Design Inclusions to improve BHS Operations, Maintainability, and Safety:

1. Don't spare the Maintenance Platforms
2. Utilize Machine Guarding consistent with general industry
3. Require 3D Scanning vs. As-Built drawings
4. Require Simulation and Pre-installation Emulation
5. Apply common-sense and applicable standards to E-Stop placement
6. Leverage Existing Technologies vs. Unskilled Labor
7. Specify Common & Readily-Accessible Components
8. Eliminate/reduce Single Points of Failure
9. Conduct robust Throughput testing using realistic conditions
10. Include TCO ***(and Safety)*** in Evaluations for Project Award

INFORMATIVE REFERENCES

OSHA CFR29 subpart N

OSHA 1926.555

ANSI/NFPA 70 (NEC) National Electric Code

ANSI/NFPA 79 Electrical Standard for Industrial Machinery

ANSI/ASME B20.1 Safety Standard for Conveyors and Related Equipment

ANSI B11.0 American National Standard - Safety of Machinery – General Requirements and Risk Assessment

ANSI B11.19 American National Standard for Machines – Performance Criteria for Safeguarding

ANSI/PMMI B155.1 Safety Requirements for Packaging Machinery and Packaging Related Converting Machinery

ANSI/RIA R15.06 American National Standard for Industrial Robots and Robot Systems – Safety Requirements

ISO 10218-1 Robots and Robotic Devices – Safety Requirements for Industrial Robots Part 1: Robots

ISO 13849-1 Safety of machinery – Safety – related parts of control systems – Part 1: General principles for design

IEC 62061 Safety of Machinery – Functional Safety of Safety – related electrical, electronic, programmable electronic control systems

IEC 60204 Safety of Machinery – Electrical Equipment of Machines Part 1: General Requirements

ISO 13850 Safety of Machinery – Emergency Stop – Principles for Design

IABSC Risk Assessment White Paper