HOW TO GET THE MAXIMUM LIFE OUT OF YOUR ESCALATOR HANDRAILS

by Field Technical Services, EHC

Overview

Escalator handrails are complex – they must be extremely flexible while remaining dimensionally stable. Handrails are required to perform a number of functions: bend forward and backward as they pass through the drive, maintain a constant length, be strong enough not to snap and be absolutely rigid in their profile. All of the components within the handrail that preserve flexibility and rigidity must be cured together in a way that ensures the components stay together while in use on the application.

It is essential that you select a product from a trusted supplier to be sure that the handrail lip dimensions do not grow to the point where the gap between handrail lip and balustrade can pinch fingers or be easily pulled from the guides. Neither must the lip dimensions decrease causing interference with the balustrade, excessive friction, heat, slippage and premature handrail failure. Traditionally, escalator handrails have been made from rubber compounds. New technology has allowed for the use of thermoplastic elastomers resulting in a product that excels on escalators or walks in many ways that rubber handrails cannot.

Installation

The majority of escalator handrails are installed endlessly in the factory, however, in some cases it is preferable to order open-ended handrails and have them spliced on the jobsite. It is, in some cases, difficult to accurately calculate the length of the handrail that is needed for new construction units. In this case, the best solution is to overestimate the length and have the handrail spliced to fit at the jobsite. Another remarkable benefit of splicing handrails onsite is that it can save significant time, reducing the total unit downtime – a handrail can be spliced onsite in less than five hours, two handrails in less than eight hours. Compared to the time required for endless installations, the cost in time and money is substantial.

Maintenance

Proper handrail maintenance is critical in prolonging the life of your handrail.

Tensioning Handrails

One of the most common factors that affect handrail life is over-tensioning of the handrail. While some types of escalators require tension in order for the handrail to drive, most modern units do not. It is very important for the unit to be set up with the appropriate amount of tension for the system, as too much slack can be as dangerous as too much tension.

Handrail Cleaning

Routine cleaning of escalator handrails is perhaps the most important and most neglected handrail maintenance procedure. Controlling a rubber handrail’s accumulation of operational grime and residue maximizes the handrail’s operating efficiency and service life, as well as promoting a more pleasant ride for pedestrians. Due to its proximity to the handrail guide and drive wheels, the handrail underside requires extra attention and must be carefully cleaned on a regular basis in addition to all the handrail components, such as guides, newel ends and take-ups.

With the introduction of thermoplastic handrails, routine cleaning is simplified and offers superior results over rubber handrails. If you have customers who insist on pristine handrails, consider this new type of handrail. At the time of installation, thermoplastic handrails do not have to be cleaned as they are provided with a removable protective film that can be left in place until after installation. The handrail won’t get scratched or gather debris while transporting through a construction site. Another benefit to thermoplastic handrails is that polishing is not required following a routine cleaning. Rubber handrails should be polished after cleaning to protect the porous surface until the next cleaning.

Handrail Storage

Unless stored under ideal conditions, rubber handrails will age to some degree, but this will be greatly accelerated if exposed to light (especially sunlight), heat and humidity. During storage, rubber handrails may develop a waxy, protective haze over the rubber cover. This is the normal migration of a protective wax in the rubber to the surface to guard the rubber handrail against aging.

Storage recommendations:

◆ Store in a dark, cool and dry environment, with a low relative humidity.
◆ New handrails are best stored in their original packaging.
◆ Used handrails should be coiled up according to handrail manufacturers’ coiling procedures, avoiding excessively tight coils or kinks in the handrails.
◆ Avoid storing in penthouses or elevator pits, as both locations leave the handrail susceptible to high temperatures as well as oil and moisture contamination.
◆ After storage, uncoil handrail and let it “relax” in that state for at least 24 hours before installing on the escalator.
◆ The surface of a stored handrail will require cleaning before installation.

Troubleshooting

What to do if your handrail is running at a different speed to the unit (slippage)? Handrail slippage is usually a result of improper handrail set up, but can also be a sign that the handrail slider ply is wearing out. The following items can all contribute toward a slippage problem:

◆ Excessive handrail tension;
◆ Improper adjustment of the pressure belt or rollers around the driver(s);
◆ Rubberized drive surface is hard, shiny or glazed;
◆ Contaminated handrail driver or handrail drive surface, e.g., wax or other lubricants;
◆ Seized idler or newel end rollers;
◆ Sources of excess drag along the handrail’s path (accumulation of dust or debris can sometimes be an indicator of drag area);
◆ Flat spots or excessive wear of handrail drive surface.
**EDUCATIONAL FOCUS: ESCALATORS**

**What Does it Mean if the Handrail is Hot?**

Unless in direct sunlight, a handrail should run at very close to room temperature and be cool to the touch. A hot handrail is a symptom of trouble ranging from over tensioning to alignment or drag problems. Over tensioning is by far the most common cause of excessive heat. To test for over tensioning, stop the escalator and take the bottom six feet (1.8 meters) of handrail off of the guide. If you cannot lay it down flat along the bottom curve of the escalator, there is not enough slack handrail on the unit. Over tensioning can cause permanent and fatal damage to the handrail such as lip cracking and slider wear. While increasing the handrail tension is a common response to handrail slipping, it often increases slippage and should not be practiced.

**New Handrail Developments**

**Anti-Bacterial Additives**

Thermoplastic handrails can be ordered with an optional anti-bacterial agent – ideal for keeping handrails germ free.

**Thermoplastic Handrails**

Traditionally, escalator handrails have been comprised of rubber compounds. The latest technology has allowed for the introduction of thermoplastic handrails. Currently, there are more than 200,000 meters in operation globally. These new handrails run with less slippage and often require less power to drive. An extraordinarily tough cover helps prevent vandalism, is easy to clean, and has an extremely glossy appearance. The small diameter pressure rollers opposite the drive wheels of the typical linear drives put high stresses on the body of the handrail. The pressure can distort the handrail and cause heat buildup, increased rolling resistance and possible delamination. As a result of many years of intensive engineering, thermoplastic handrails have been successfully developed to avoid these linear drive vulnerabilities while also displaying high performance on reverse bend drives.

**Exotic and Customized Handrails**

Thermoplastic handrail technologies are allowing the introduction of specialty finishes such as metallic and fluorescent colors. Historically, color handrails have been difficult for building owners to maintain but with thermoplastic handrails, whose smooth, glossy surface does not trap dirt or grease, the colors stay vibrant throughout the handrail life. Architects can specify Pantone colors to match building decors and department stores can purchase handrails that match their corporate identity. You will also see safety messages, advertising and seasonal decorations applied to handrail surfaces in Europe, Asia and North America (patents pending).

The market for escalator handrails will be much different in years to come, as with the technology available, building owners and designers can demand highly decorative appearances, that they could only dream of until now.
Ideally, to operate satisfactorily, an escalator should run between tracks which lie in parallel vertical planes throughout their length. Also, a line joining corresponding points, for example, track mounting points, on opposite sides of the escalator should be precisely normal to these planes. If either of these conditions are not met, the escalator steps cannot run smoothly.

In the case of London Transport, before the King’s Cross disaster of 1987 (see ELEVATOR WORLD, January-March 1988, March and May 1989, and February 1991), escalator misalignments were largely accommodated by simply providing sufficient space between the sides of the steps and the skirting panels, allowing the steps a degree of lateral movement. However, since that tragedy, and following the Fennel report, much tighter specifications have been enforced, among which is one restricting this space to 4mm (.2in.). The imposition of this restriction has resulted in skirt and step side wear and production of substantial noise in many escalators. In some cases, they have had to be taken out of service.

Until recently, no satisfactory method existed for successfully rebuilding London Transport escalators to the tolerances required by the Fennel report, and many of them continued to give trouble even after a rebuild. This article describes an escalator surveying procedure developed by the author and used over the past three years, enabling escalators to be successfully rebuilt to required spacing tolerances. The procedure has been applied in 17 cases and is currently being used at Wood Green and Notting Hill Gate Stations as well as Oxford Circus where the No.8 machine was recently rebuilt by an outside contractor but failed to meet requirements.

The method has been strikingly successful at Moorgate where machine No.3 had never, since first installed, functioned properly because of a sideways bend in the escalator track at the start of the incline. This particular job, now functioning perfectly, necessitated a complete realignment and reconstruction but, nevertheless, was completed by your author and a team of eight men in 16 weeks.
Center Line Alignment

Correctly aligning the tracks of an escalator during rebuild would be feasible if a line could be established running from end to end of the escalator and lying in a vertical plane parallel to the direction of motion of the escalator. From this line, one would be able to measure the perpendicular distance to each track at a number of points along the escalator. By equalizing these distances, one could position the tracks parallel to this line and, therefore, confine them to two parallel vertical planes throughout their length, as required.

If the escalator landings are fairly short, such a line can be established by simply stretching a wire between two frames placed beyond the extreme ends of the escalator and, by means of plumb lines, use it to align the tracks. Most of the escalators in London Transport Underground stations, however, have long landings and low ceilings, making this impossible. A wire the length of the escalator would normally be bent at two “diversion points” (X and Y in Figure 1). There is no guarantee, however, that the points A, X, Y and B shown in Figure 1 all lie in a vertical plane.

This method overcomes this problem, firstly by positioning the wire so that only one diversion point is required; secondly by suspending the wire itself at a point some six feet above the diversion point. Figure 2 shows the arrangement, viewed from the side. Wire ends P, R and S are fixed to the brackets which can each be moved along fixed horizontal rods set at right angles to the escalator. The junction point Q is entirely free. X is a plumb line hanging between the tension carriage guide rails, and Y is a plumb line hanging between the upper step chain sprocket wheels. By suspending a plumb line from a point on the S bracket to bring the wire SQ exactly into line with it, the plane containing the points P, Q, R (and S) is made vertical. The crux of the surveying method is shown in Photo 1. A movable plumb line may now be suspended from various points along PR from which the horizontal distance between the vertical plane, and the escalator tracks at these points can be measured.
The surveying procedure is necessarily tedious. Initially, it requires repeated adjustments of the positions of the P, R and S brackets on their respective horizontal supports until the plumb lines at X and Y hang exactly over the midpoint between the rear tension carriage guide rails and the midpoint of the top shaft sprocket axle, respectively, with SQ in line with the plumb line from the S bracket. Once this has been achieved, a “center line,” P X Q Y R, has been established, and the track survey itself can begin.

The survey is normally conducted with the escalator dismantled, i.e., with the chains and steps removed. The first step is to measure and record the horizontal distance at a number of points between each track-side flange and the center line. This requires the use of a movable plumb line suspended from successive points along the centerline wire. The results are plotted as a chart, as shown in Figure 3. The chart then shows the amount the tracks have to be moved sideways to make the opposite track flanges parallel and equidistant from the center line throughout their length.

**Vertical Adjustment of Track Position**

The foregoing procedure ensures that the tracks are parallel and straight, viewed from above. It is then necessary to assure that corresponding points on the opposite tracks are precisely at the same level. This involves adjusting the track position in a vertical plane at each mounting point. The needed adjustment is determined using a very large T-square (Figure 4). AB is a round rod the length of which is some 40mm (1.6in.) less than the average distance (typically 1,278mm [50-1/3in.]) between opposite chain wheel guide flanges. The ends AB are laid on the wheel running surfaces and the end C rests on an escalator cross-member. The edge CD of the T-square axis is made to lie exactly below the centerline wire by means of plumb lines hanging just clear of the edge at C and D. The levels of the two running surfaces are equalized using a highly sensitive spirit level placed on the rod AB at S. Any inaccuracy in the T-square itself is cancelled by repeating the measurements with the T-square turned over.

**Sprocket Adjustment**

This entails ensuring that the axle connecting the sprocket wheels is perfectly horizontal and perpendicular to the center line. This can be difficult but involves no new principle.

**Conclusion**

This method of escalator track adjustment has been used successfully on a number of London Transport escalators and accepted as standard procedure by the Lifts and Escalators Managers Division. It can be modified to suit any escalator. The survey technique is necessarily tedious and time-consuming but can achieve extremely close accuracy, being limited only by the time and care spent conducting the survey. It has the advantage of being simple in principle. Typically, dismantling, surveying and reassembling an escalator occupies eight men about 10 weeks.

*Marcus Hoffmann de Visme* graduated from the North Staffordshire Polytechnic in 1984 with an honors degree in Mechanical Engineering. While studying, he was employed as a student engineer by G.E.C. Switchgear Ltd., for whom he worked until 1986. In 1988, he joined the Lift and Escalator Engineers’ Division of London Underground as a graduate trainee, moving after a year to the Lift and Escalator Managers’ Division as a test engineer, dealing mainly with the mechanical aspects of major escalator refurbishment projects.

Reprinted from the September 1993 issue of ELEVATOR WORLD
EDUCATIONAL FOCUS: ESCALATORS

A PROPOSED SOLUTION TO ESCALATOR TENSION CARRIAGE PROBLEMS

by Marcus Hoffmann de Visme, BSc

Escalators essentially consist of two long sprocket chains running parallel to each other, with steps pivoted on axles between. Steps are fitted with wheels running on carefully positioned tracks supporting the chains, steps and passengers. These tracks also control the formation of "steps" on the escalator incline and "landings" at the top and bottom of the escalator. The chains are driven by a pair of sprocket gears locked in axial alignment and mounted on a shaft at the top of the escalator, usually called the top shaft. At the bottom of the escalator, the chains run around a similar pair of sprocket gears mounted on an idler shaft.

In order to maintain the necessary tension in the chains, the idler shaft and its bearings are mounted on a frame, called the tension carriage, which can move horizontally along the lower escalator landing in the line of the escalator motion. On most large escalators, the tension carriage is rectangular in shape and tensioned on each side by independent mechanisms providing equal tension. These mechanisms consist of either a system of springs, or preferably of a weight and lever arrangement, since weights provide a degree of inertial damping.

It is essential that the faces of both pairs of sprocket gears remain exactly parallel to, and equidistant from, an imaginary vertical plane through the escalator center line. As far as the idler shaft is concerned, the tension carriage must not suffer distortion due to unequal chain tensions and must be constrained to move strictly in the desired direction by some guiding mechanism. This article considers the difficulty of fulfilling the latter requirement using conventional guiding mechanisms and proposes an alternative mechanism based on a well-known mechanical principle.

Problems Associated with Escalator Tension Carriages

The usual tension carriage used on the London Underground units consists of a rectangular steel frame carrying the idler shaft, bearing assembly and all trackwork, over which the wheels run on their way around the idler shaft.

![Figure 1 – Left and right half tracks viewed from above](image.png)
EDUCATIONAL FOCUS: ESCALATORS

long, and passengers are encouraged to stand on the right-hand side. Additionally, since the Kings Cross fire in 1987, restrictions on the use of certain types of chain lubricant have been imposed, resulting in the appearance of kinks in the chains, which effectively reduce their lengths in an unpredictable way.

The effect of chain length difference causes the tension carriage to distort and slew. While distortion can be overcome by bracing, current methods of guiding the carriage are unable to prevent slewing. In the early days, this did not matter much since (a) the tension carriage was long—some six feet or so—and unable to slew significantly within its guides, (b) the comb system could tolerate considerable misalignment and (c) half tracks were capable of resisting the slewing effect.

The Watt's Link

Your author recently suggested tension carriage slewing could be completely eliminated by fitting the tension carriage with a pair of Watt's links instead of the usual guide arrangements. This could be achieved simply and inexpensively by using sealed motor vehicle-type "sealed for life" track rod and steering components without entailing major escalator modification. Servicing would then merely consist of unit replacement.

The Watt's link is a very simple mechanical device for producing linear motion invented by the famous steam engineer James Watt more than 150 years ago. Figure 2 is a schematic diagram of the link. A and B are fixed points. AP and PQ are arms of equal length (this is not a requirement of the link but is convenient for this application). The arms pivot freely about A and B, respectively. Ends P and Q are joined by a third arm, PQ, which pivots freely about ends P and Q. R is the midpoint of PQ. AP and BQ are the undisplaced positions of AP₀ and BQ₀, defined when AP and BQ are parallel. In this position, the point R occupies the position O, the origin of axes Oₓ and Oᵧ, and the third arm makes an angle α with Oᵧ.

For AP and BQ of unit length, the locus of point Rₓ,y, as the arm BQ is rotated about B, is given by:

\[
x = \frac{2}{2} \left( \cos \phi - \cos \theta \frac{\sin \phi + \sin \theta}{2} \right),
\]

\[
y = \frac{2}{2} \left( \cos \phi - \cos \theta \frac{\sin \phi + \sin \theta}{2} \right)
\]

where LQ₀ BQ= θ and LP₀ AP= φ. This shows that when θ and φ are both small (i.e., when R is in the neighborhood of 0), the locus of R is substantially coincident with the y-axis. The actual locus can be calculated in terms of θ, for various values of α, using the somewhat complicated formula relating θ and φ:

\[
\phi = \cos^{-1} \left[ \frac{3 - 4a \sin \alpha - 2 \cos \theta - 2a \sin (\theta - \alpha)}{\sqrt{5 - 4a^2 - 8a \sin \alpha - 4 \cos \theta - 4a \sin (\theta - \alpha)}} \right]
\]

\[
\tan^{-1} \left[ \frac{2a \cos \alpha - \sin \theta}{2 - 2a \sin \alpha - \cos \theta} \right]
\]

where a=PQ/AP. This formula holds for θ lying between its two values, for which the points A, P and Q are collinear.

Figure 3 (a, b and c) shows the locus of R with AP = BQ = 30in. and PQ = 18in., for α = 0°, 2.5° and 5.5°. With α = 2.5°, we see that the maximum departure from a straight line is ±1/1000 inch over a distance along the y-axis of 16-1/2in. – an incredibly small deviation.

Figure 4 shows the proposed tension carriage installation. Where the four points A, B, A' and B' are accurately placed symmetrically on either side of the escalator's center line, the two Watt's links are lettered A P R Q B and A'P'R'Q'B'.

The advantages of such a system are:

1. Since the links have no free play, the system can be...
EDUCATIONAL FOCUS: ESCALATORS

used on a short tension carriage frame operating in a confined space;
2. The carriage cannot slew, as it can only move in a straight line parallel to itself, irrespective of differing tensions on the idler sprockets. Risk of seizure at the half-tracks is largely removed;
3. Lateral forces applied to the pivots R and R' are evenly divided between the two sides of the escalator truss structure, thereby halving the stress on each truss; and
4. The system can be fitted to most existing installations, and once correctly set up, is easy to maintain.

Conclusion

Many escalator failures on the London Underground result from half-track seizure and other damage due to slewing of the tension carriage as it moves back and forth between its side guides. This article proposes the replacement of the side guides by two accurately positioned Watt’s links attached to the tension carriage frame. It is suggested that not only would such a system entirely eliminate carriage slew, but maintenance would be considerably simplified.

Reprinted from the June 1994 issue of ELEVATOR WORLD

Marcus Hoffmann de Visme graduated from the North Staffordshire Polytechnic in 1984 with an Honor’s degree in Mechanical Engineering. While studying, he was employed as a student engineer by G.E.C. Switchgear Ltd., for whom he worked until 1986. In 1988, he joined the Lift and Escalator Engineers’ Division of London Underground as a graduate trainee, moving after a year to the Lift and Escalator Managers’ Division as a test engineer dealing with mechanical aspects of major escalator refurbishment projects.