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Understanding Scissors Lift Deflection

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DEFLECTION DEFINED

Deflection in scissors lifts can be defined as the resulting change in elevation of all or part of a scissors lift assembly, typically measured from the floor to the top of platform deck, whenever loads are applied to or removed from the lift.

IS DEFLECTION NORMAL?

ANSI MH29.1 – *Safety Requirements for Industrial Scissors Lifts* states that ". . . all industrial scissors lifts will deflect under load". The industry standard goes on to outline the maximum allowable deflection based on platform size and number of scissors mechanisms within the lift design. If so commonplace, then why doesn't the topic of acceptable deflection come up more often? Likely because it is not critical to most scissors lift applications. The majority of the approximate 50,000 scissors lifts sold in the U.S. each year are used in manual material handing applications where the lift interfaces directly with a worker that must position the load at approximate, variable – typically ergonomic – work heights.

Scissors lift deflection becomes more critical in material handling applications where the lift must interface with adjoining, fixed elevations – especially when transferring rolling loads. In these cases, it is important that any difference in elevation between adjoining surfaces during material transfer be minimized, if not eliminated. Rolling loads can include wheeled loads (carts, walkies, pallet jacks, etc.), where transfer elevation differences of 1/2" or more can be tolerated. Conveyed loads, on the other hand, are usually less tolerant of elevation changes during material transfer. In conveyor system applications, scissors lift deflections must typically be limited to less than 1/2" where adjoining transfer surfaces meet.

WHAT CAUSES DEFLECTION?

Before attempting to discuss how to limit scissors lift deflection, it is important to understand the contributing factors to a lift's total deflection. An open, or raised, scissors lift acts very much like a spring would – apply a load and it compresses, remove a load and it expands. Each component within the scissors lift has the potential to store or release energy when loaded and unloaded (and therefore deflect). There are also application-specific characteristics that may promote deflection. Understanding these Top 10 root causes helps to pinpoint and apply effective measures to limit deflection.

Scissors Legs
Leg deflection due to bending is a result of stress, which is driven by total weight supported by the legs, scissors leg length, and available leg cross section. The longer the scissors legs are, the more difficult it is to control bending under load. Increased leg strength via increased leg material height does improve resistance to deflection, but can create a potentially undesirable increased collapsed height of the lift.

Platform Structure
Platform bending will increase as the load's center of gravity moves from the center (evenly distributed) to any edge (eccentrically loaded) of the platform. Also, as the scissors open during raising of the lift, the rollers roll back towards the platform hinges and create an increasingly unsupported, overhung portion of the platform assembly. Eccentric loads applied to this unsupported end of the platform can greatly impact bending of the platform. Increased platform strength via increased support structure material height does improve resistance to deflection, but also contributes to an increased collapsed height of the lift.

Base Frame
Normally, the lift's base frame is mounted to the floor and should not experience deflection. For those cases where the scissors lift is mounted to an elevated or portable frame, the potential for deflection increases. To effectively resist deflection, the base frame must be rigidly supported from beneath to support the point loading created by the two scissors leg rollers and the two scissors leg hinges.

Pinned Joints
Scissors lifts are pinned at all hinge points, and each pin has a running clearance between the O.D. of the pin and the I.D. of its clearance hole or bushing. The more scissors pairs, or pantographs, that are stacked on top of each other, the more pinned connections there are to accumulate movement, or deflection, when compressing these running clearances under load.

Hydraulic Circuit – Air Entrapment
All entrapped air must be removed from the hydraulic circuit through approved "bleeding" procedures – air is very compressible and is often the culprit when a scissors lift over-compresses under load, or otherwise bounces (like a spring) during operation.

Hydraulic Circuit – Fluid Compressibility
Oil or hydraulic fluid will compress slightly under pressure. And because there is an approximate 5:1 ratio of lift travel to cylinder stroke for most scissors lift designs (with the cylinders mounted horizontally in the legs), there is a resulting 5:1 ratio of scissors lift compression to cylinder compression. For example: 1/16" of fluid compressibility in the cylinder(s) translates into 5/16" of vertical lift movement.

Hydraulic Circuit – Hose Swell
All high pressure, flexible hosing is susceptible to a degree of hose swell when the system pressure is increased. System pressure drops slightly because of this increased hose volume, and the scissors table compresses under load until the maximum system pressure is re-established. And, as with compressibility, the resulting lift movement (deflection) is 5 times the change in oil column height in the hosing.

Cylinder Thrust Resistance
Cylinders lay nearly flat inside the scissors legs when the lift is fully lowered and must generate initial horizontal forces up to 10 times the amount of the load on the scissors lift due to the mechanical disadvantage of their lifting geometry. As a result, there are tremendous stresses (and resulting deflection) placed on the scissors inner leg member(s) that are designed to resist these cylinder forces. And, as already mentioned above with any changes in column length along the line of the lifting actuator(s)/cylinder(s), the resulting vertical lift movement is 5 times the amount of deflection or movement of cylinder hinge points mounted to leg cross members.

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Load Placement
Load placement also plays a large part in scissors lift deflection. Off-centered loads cause the scissors lift to deflect differently than with centered or evenly distributed, loads. End loads (in-line with the scissors) are usually shared well between the two scissors leg pairs. Side loads (perpendicular to the scissors), however, are not shared as well between the scissors leg pairs and must be kept within acceptable design limits to prevent leg twist (unequal scissors leg pair deflection) – which, in addition to platform movement due to deflection, often results in poor roller tracking, unequal axle pin wear, and misalignment of cylinder mounts.

Lift Elevation During Transfer
As mentioned above, degree of deflection is directly related to change in system pressure and change in component stress as a result of loading and unloading. Scissors lifts typically experience their highest system pressure and highest stresses (and therefore the highest potential for deflection) within the first 20% of total available vertical travel (from the fully lowered position).

WHAT CAN BE DONE TO LIMIT DEFLECTION?

There are a variety of proven methods to reduce scissors lift deflection, with varying design and cost impacts to accomplish each. Listed below are the most common of these methods, in no particular order, to provide the reader an understanding of where to begin when attempting to reduce or eliminate deflection during load transfer (i.e. applying a load, or removing a load).

Select a Lift with a Design Capacity Greater Than Required for the Application
Simple and effective. Most scissors lifts designed for duty at higher capacities will experience less stress in all structural components, as well as lower system pressures, at lower, or de-rated, working capacities. Reduced stresses & pressures always result in reduced deflection. The amount of this reduction varies depending on the lift's design, so consult the manufacturer to obtain a more specific estimate of reduction in deflection.

Minimize Potential for Air Entrapment
Scissors lift manufacturers provide an approved method of "bleeding" entrapped air from a new or repaired hydraulic system which may have had air introduced. This usually involves operating an empty lift through multiple cycles, and then safely cracking open fittings near high spots in the system where air accumulates. Refer to the O&M manual for this procedure.

Limit or Eliminate Hosing
Flexible hose lengths should be limited wherever possible and replaced with pipe or mechanical tubing as practicable to minimize or eliminate swell as the system pressure fluctuates.

Use Mechanical Actuators in lieu of Hydraulic Actuators
Although it is more difficult, and more expensive, to achieve high vertical lifting forces with mechanical actuators, they do eliminate the issue of fluid compressibility and provide a more accurate and repeatable means of achieving – and holding – a desired transfer elevation.

Avoid Transfer of Loads Within First 20% of Lift's Travel
To minimize stresses and deflection at transfer elevations, it is critical to design the conveyor or transfer system to ensure that these elevations are above the scissors lift's "critical zone" of the first 20% of the lift's available travel.

Transfer Loads Over Fixed End of the Platform
First, if possible, loads should not be transferred over the sides of a raised scissors lift. It is much more difficult to control deflection when the load is not shared equally between the two scissors leg pairs. Make it rule to only transfer over the ends of the lift – in line with the scissors legs. Second, load transfer should be made over the hinged, or fixed, end of the lift platform to avoid placing concentrated loads on the less supported, overhung end of the platform – provided the platform is equipped with "trapped" rollers, or is otherwise capable of withstanding this edge loading without risk of the platform tipping up or losing contact with the rollers.

Ensure that the Base Frame is Lagged Down and Fully Supported
First, base frames should be adequately attached to the surface on which they are mounted. Base frames that are not bolted, welded, or otherwise attached to withstand the upward forces created by eccentric loading of the platform will contribute to deflection by bending or moving while resisting such forces. Next, bases must be rigidly supported beneath the entire perimeter of the frame in order to withstand without deflection the four point loads imposed upon the frame from above by the four scissors legs – (2) moving roller points and (2) fixed hinge points.

Platform Locking Pins
When there is no alternative to transferring loads over the sides of a lift, or whenever lift deflection must be held to near zero in any transfer orientation, consider using platform locking pins. These pins can be manual or powered, and mounted beneath the scissors lift deck or an adjoining fixed landing. The pins are extended into receivers located in the mating elevated structure during load transfer, and then retracted before the lift can be operated again.

Use Vertical Acting Actuators in lieu of Horizontal Mounts
Some permanent installations may accommodate actuators which are mounted vertically beneath the lift instead of horizontally inside the lift structure. Vertical orientation of the actuators provide a 1:1 ratio of lift travel to actuator stroke instead of the 5:1 ratio normal with horizontal mounting of the actuators inside the scissors. This means a 1:1 ratio of lift deflection to actuator compression, 80% less than the 5:1 ratio experienced normally. Vertical mounting and pushing upward against underneath side of the platform to raise the lift also eliminates the high stresses usually exerted at the actuator thrust inner leg member(s).

SUMMARY ON DEFLECTION

Deflection is a normal and expected characteristic of industrial scissors lifts. And though odds are that most scissors lift users have not had to concern themselves with this issue because their lifting application is fairly immune to the effects of deflection, there is always a chance that it matters greatly. ANSI MH29.1accurately points out that "It is the responsibility of the user/purchaser to advise the manufacturer where deflection may be critical to the application." Though deflection is easier to qualify than it is to quantify, there are industry best practices which can be applied to reduce the impact or amount of deflection being experienced.