Hydraulic Elevator Systems – Reducing Common Failures

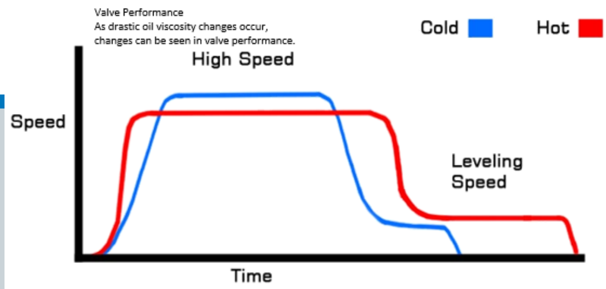
An in-depth look at temperature, pressure and contamination issues from design, installation and maintenance perspectives resulting in the best ride performance and equipment longevity possible

by Landon Smallwood

An understanding of temperature, pressure and contamination has always been a key factor in maintaining a properly running hydraulic system. In hydraulic elevators, controlling these key aspects of the hydraulic system will increase the life span, as well as ensure safe operation for the public. These important issues should be getting ever-increasing attention. Let's look at these topics in detail and together with the goal of preventing common failures that are driven by temperature, pressure and contamination. Ensuring you have the proper tools for the job (tachometer, pressure gauge) is an important first step to troubleshooting most problems.

Temperature

To understand the effects of temperature on a hydraulic system, we first look at how temperature affects the viscosity of the oil. In simple terms, as oil cools it becomes thicker, and as it warms it becomes thinner. This thickening and thinning of the oil (change in viscosity) will change the ride quality and up speed of the elevator based on how easily the oil can flow through the control valve and the efficiency of the pump at the given temperature. When the oil is cold (thick), it will be sluggish and slow moving through the control valve, causing slower/smoother accelerations and transitions all while the pump is more efficient, creating a slightly faster high speed. When the oil warms (thinner), it travels more quickly through the control valve causing faster/harder accelerations and transitions while the pump is less efficient, causing a slight loss of up high speed.



Temperature (heat) in a hydraulic elevator system is primarily built when oil is being recirculated through the control valve back to the tank. Therefore, the majority of the heat is generated during the up leveling of the elevator. There are many factors that will affect the time spent in leveling, such as slow-down distance and up-transition adjustment, with the most overlooked factor being the minimum oil temperature.

The industry standard for slow down distance of a hydraulic elevator is 2 in. for every 10 ft/min of car speed not to exceed 6 in. for every 25 ft/min. To prevent overadjustment of the valve and an extended leveling distance, it is recommended to always use the 2 in. for 10 ft/min rule as the default. In rare cases where the

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Learning Objectives

After reading this article, you should have learned:

- How temperature affects control valve performance.
- How to assess temperature variables.
- How to identify available solutions for a given situation.
- How pressure affects control valve performance.
- How contamination is introduced into a hydraulic system.
- How to identify preventative actions to maintain a clean hydraulic system.

Value: 1 contact hour (0.1 CEU)

This article is approved for Continuing Education by NAEC for CET and CAT.

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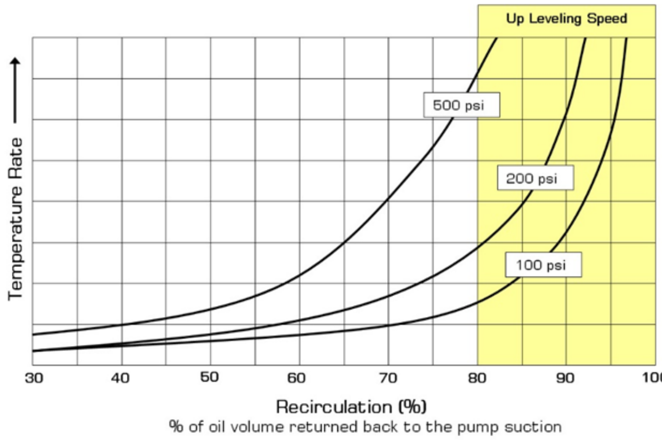


system pressure is low (<100 psi) with a fast contract speed of 150-plus ft/min, extending the distance to 6 in. for 25 ft/min may be necessary. Verifying the slow-down distance on install, prior to valve adjustment, is an important factor for minimizing leveling distance to help manage temperature swings. Keep in mind that most controllers will default to 6 in. for every 25 ft/min and should be shortened to 2 in. for every 10 ft/min when possible.

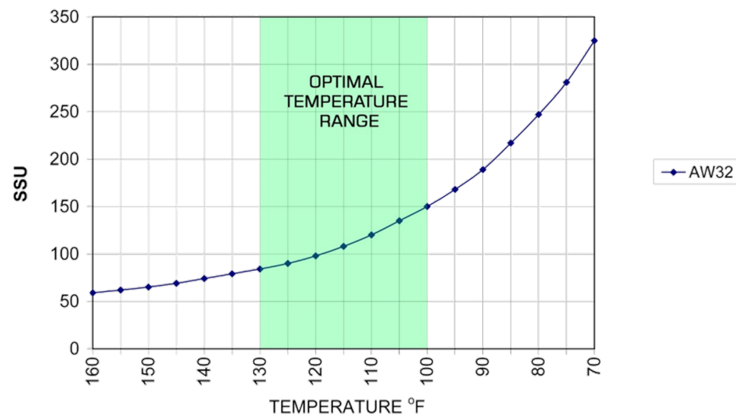
SLOW DOWN DISTANCE VS. CONTACT SPEED		
Contact Speed (ft/min)	2 in. for 10 ft/min	6 in. for 25 ft/min
75	15 in.	18 in.
100	20 in.	24 in.
125	25 in.	30 in.
150	30 in.	36 in.
200	40 in.	48 in.

Up transition, which is defined as the deceleration from up high speed to up leveling speed, should be adjusted to allow sustained stable leveling for about 3 to 6 in. when the oil is at its coldest temperature. As this distance is difficult to judge unless riding on the car top, many mechanics default to counting seconds to determine if the car is leveling the appropriate distance. When using time to determine leveling distance, two factors must be considered. First is the leveling speed; second is when to start the count. A good metric to aim for when using time to estimate up leveling distance is 2 to 3 s of stable leveling at around 10 ft/min.

The minimum oil temperature of the system is often the most overlooked factor when adjusting hydraulic elevator systems. Control valves always need to be adjusted for the coldest oil the system will experience on any given day. This is due to how oil viscosity changes the performance of the valve. When control valves are adjusted with a higher than nominal temperature, they will be prone to delayed accelerations or transitioning through the floor when the oil is at its coldest. Controlling the minimum oil temperature is very important to maintain proper ride quality throughout the day. There are two main ways to control the minimum oil temperature: tank heater or running the pump and motor to recirculate the oil.

The optimal temperature range for a 32-wt hydraulic fluid is between 100°F (37.8°C) and 130°F (54.4°C). When the fluid is within this range, the viscosity change is relatively stable while still being viscous enough to allow the pump and internal components of the valve to work properly. When dealing with temperature issues, this range is important to keep in mind. On most systems, the first step in diagnosing and fixing high temperatures is to review the low temperature. If an elevator is experiencing a heat issue, raising the minimum temperature may be the solution that fixes the issue by stabilizing the change in viscosity.

Now that we understand how heat is generated in the hydraulic elevator system, we can begin to combat this issue.



When evaluating a system that has constant over-temperature issues, the first question to ask yourself is "What is the minimum temperature of the oil?" If the answer to this question is <80°F (26.7°C), then the first step will be to add a method to maintain the minimum temperature between 95°F (35°C) and 100°F (37.8°C). By adding heat to the system and adjusting the valve to maintain minimal leveling distance at the set minimum temperature, we will eliminate extended leveling times that drive most temperature issues. Extended leveling times lead to a thermal runaway scenario where the more temperature that is added to the system, the greater the leveling distance which, in turn, subjects the system to more heat.

The next variable to consider is the airflow of the machine room. It is typically better to exhaust the hot air from the machine room than pump cold air into the room via air conditioning (A/C). In fact, A/C in the machine room can be counterproductive to a point. If the A/C is cooling the oil in the tank below 80°F during downtime (overnight), then, typically, systems will run hotter throughout the day as the viscosity of the oil changes, creating longer leveling distances. This does not mean A/C should not be used, but that it should be monitored in such a way that it does not overperform and drop the oil temperature out of the desired range.

Another thing to consider is the placement of the tank in the machine room. Tanks are natural radiators of the heat generated inside. When a tank is placed too close to a wall, in a corner or a closet, it is hampered in its ability to dissipate heat naturally. When the tank is close to a wall, it heats up the air between the wall and tank, creating an insulation barrier that reduces the tank's natural ability to shed temperature. A simple

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way to counteract this is to place a small 5V fan between the tank and the wall to increase airflow around the tank, preventing the insulation barrier from reflecting the heat back into the tank. Another tip for the tank is to keep the oil level at the highest mark possible to provide more surface area for heat dissipation.

Oil coolers are another method for maintaining proper oil temperature. An issue that is common around the elevator industry is to mount the cooler on the outside of the tank instead of piping it into the system in such a way that the hot exhaust is blown outside the machine room. If the exhausted air from the cooler is heating the room, there comes a point that the cooler will no longer drop the temperature of the oil, as the ambient temperature in the room is above the effective range to cool the oil. This can compound heat issues, as we are using another pump to move the oil, creating more heat while not allowing the air-cooling method to be as efficient as it should be.

As all systems differ in machine room layout, piping, volume of oil and many other variables, one solution may not work on all elevators. The best place to start will always be with the variables that are easily controlled by the mechanic on-site. By setting the slow-down distance to the minimum recommended and adjusting the valve to a short up leveling distance at the minimum temperature, most heat problems will be solved. If the elevator is then still having heat issues, raising the minimum oil temperature to approximately 100°F (37.8°C) and readjusting the valve to maintain a short up leveling distance will be the next step. If heat problems are still present at this point, then an oil cooler and external exhaust/A/C may need to be installed to lower the overall temperature.

Pressure

Understanding how pressure affects valve performance is key to maintaining proper ride performance throughout empty and loaded conditions. When most people think of pressure issues, they are primarily concerned with the up direction; however, most of the issues found due to pressure in hydraulic elevators are from a loss of pressure in the down direction. As pressure controls how quickly the internals of the valve react in a given situation, it is important to understand how this affects valve performance.

When load is added to the elevator, it will increase the pressure at the valve. This additional pressure will cause everything inside the valve to move at a faster rate. When the internal components of the valve move quicker due to the increased pressure, it will cause faster acceleration and transitions, as well as affect the speed of the elevator. Up high speed will decrease slightly due to a loss of efficiency at the pump while down high speed will increase as more fluid is forced through the valve. Leveling speeds in both directions will slightly increase with load. Due to these factors, it is always recommended that the valve is adjusted empty with down speed set initially 20-30% lower than contract speed. Down high speed would then be set to contract speed with the full load in the car. If the specifications of the elevator call for the down high speed to be maintained within a certain percentage of contract speed, then a regulated valve may need to be used.

ASME A17.1 Section 8.6.5.14.1 Relief-Valve Verification of Setting and System Pressure Test. *The relief-valve setting shall be tested to determine that it will bypass the full output of the pump before the pressure exceeds 150% of the working pressure. Once this is established, test the entire system to ensure that it will withstand this pressure. It shall be resealed if the relief-valve setting is altered or if the seal is broken.*

Pressure relief being set too low is a very common problem found during initial installations of elevators. After completing the setup of an empty car, the car is loaded and suddenly the car will not run up. If this happens, it typically means that the current setting of the pressure relief is too low, not allowing the load to pick. In this situation, if the working pressure is unknown, the pressure relief adjuster will need to be adjusted so that the load will pick to determine the working pressure. Once the working pressure is known, then relief can be properly adjusted to not exceed 150% of working pressure.

Pressure drop in the down direction is one of the biggest issues found with hydraulic elevators. As noted previously, pressure controls how quickly the internals of the valve react in a given situation. If the pressure drops too far, then the internals of the valve will become slow and sluggish, causing less high speed, slow transitions and issues in down leveling. If a mechanic has persistent trouble setting the downside of a valve, the first step is to evaluate the pressure. A clean-running hydraulic system will lose between 5 psi and 20 psi on a down run. When the pressure drop is significant in the down direction, it will cause issues. If a significant drop in pressure is found, then there are two options: The first is to slow the car down until control is obtained; the second is to determine the root cause of the loss of pressure and fix the issue. There are many components that may lead to a loss of pressure in the system such as mufflers, ball valves, rupture valves, pipe size, elbows, power unit location, guide shoes and packing friction.

Mufflers, ball valves and rupture valves all add a restriction to the line, causing a change in pressure as the oil flows through them. If pressure drop is an issue, a full port ball valve may be recommended. If a rupture valve is in the system, setting it to the maximum tripping speed allowed by code (not to exceed 140% of contract speed) will reduce the restriction, as well as ensure the mufflers' pipe size is sufficient to handle the flow of the system.

Pipe size, elbows and power unit location are another factor to consider when pressure drop is an issue. Each pipe size has a recommended maximum flow to maintain a fluid velocity under 20 ft/s. When the maximum flow is approached or exceeded, it will cause turbulence in the pipe and a loss of pressure in the down direction. Each elbow in the system can also add to pressure drop as the fluid is redirected. It is always best to design the pipe run in the most efficient path for the oil flow with as few elbows as possible. Power unit location is another factor that needs to be considered during the design phase of an elevator. When a remote machine room is used or the machine room is placed on the roof, the amount of pressure

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needed to drive the oil back to the valve will need to be increased to compensate for the volume of fluid being pushed.

Pipe Size (SCH 80)	Max GPM
2 in.	185
2.5 in.	265
3 in.	410
4 in.	715

Friction in the system is the last and most common cause of pressure drop. Pressure drop due to friction is found in the hoistway and primarily caused by the packing or piston. However, guide shoes, rails and plumbness of the jack may also be a factor. When evaluating a packing and piston, the first thing to check is if the piston is carrying oil through the packing. Pistons should always have a sheen of oil coating them to maintain smooth operation. If oil is not present on the piston, then greater friction is present. Typically, if the piston is dry, then either the packing is too tight or the piston has lost the crosshatching that carries oil through the packing. An oil additive may help in this case; however, re-crosshatching the piston is the long-term solution for the issue.

Contamination

Contamination is one of the leading causes of hydraulic equipment failures. The valve, pumps, seals and piston are subject to damage due to contaminants. Secondarily, contaminants can affect how the system operates, driving overheating issues. Contaminants can be introduced into hydraulic systems in many ways, from the oil added to the system to the air that the tank breathes and everything in between. Good housekeeping practices, as well as care during installation, can negate many contamination issues within the hydraulic system.

The first line of defense against contamination will be the cleanliness of the components used during installation. The jack, piping and tank should be cleaned prior to installation to prevent any initial contamination being introduced at the beginning of the build. Failure to ensure the equipment is clean prior to installation will likely have an immediate effect on the operation of the system and cause premature failures. Once the equipment to be used is clean and it is time to add the fluid to the system, it is essential to keep in mind that the fluid from the barrel or bucket likely does not meet the cleanliness standard required in the hydraulic system. Fluid added to the system should always be run through a filtering mechanism that will clean the oil to the lowest threshold required by any component. Most valves recommend that the oil is passed through a filter to remove any particulates greater than 5 microns.

Once the system is cleaned, the valve adjusted and everything is running properly, the next step is to ensure the longevity of the system by keeping it clean. As the system itself is primarily a closed system, the entry point for external contamination is through the tank. This is due to the tank acting as a lung to the system. When the oil level is pumped to the jack, the tank replaces the oil with outside air; therefore, anything in the air is in the tank. If the machine room is dusty and dirty, so is the oil. The cleaner the machine room is kept, the cleaner the oil will stay in the long term. Secondarily, any oil added to the tank after initial installation should also be filtered. This includes any new oil, oil returned for the pit can or scavenger pump.

As the system breathes and the oil becomes contaminated over time, serious thought should be given to a scheduled filtration of the oil to extend the life of the hydraulic system. This preventive maintenance will greatly enhance the longevity of all components within the system. Any time a new valve is placed into the system, it is also recommended that the oil is filtered prior to installation. If oil is replaced in the system with new oil, keep in mind that it will have a solvent effect that will clean and dislodge material from the piping and jack. If new oil is placed into an old system, it is suggested that the oil is filtered again after a few weeks of use to remove any of the dislodged contaminants. Keeping the oil clean and free of contaminants by using proper preventive actions and scheduled maintenance will greatly enhance the lifespan of the system and create a safer environment for the passenger.

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Learning-Reinforcement Questions

Use the below learning-reinforcement questions to study for the Continuing Education Assessment Exam available online at elevatorbooks.com or on p. 125 of this issue.

- ♦ How does temperature affect control valve performance, and how are temperature variables assessed?
- ♦ How does pressure affect control valve performance?
- ♦ What is the best solution for optimal valve performance?
- ♦ Where are most pressure issues found?
- ♦ How is contamination introduced into a hydraulic system?

Accounting of Time for Article

Understanding how temperature and pressure affects control valve performance

- ♦ 30 minutes (Pages 101 – 105) Preventative maintenance to maintain a clean hydraulic system
- ♦ 30 minutes (Page 106)

ELEVATOR WORLD Continuing Education Assessment Examination Questions

Read the article **"Hydraulic Elevator Systems – Reducing Common Failures"** (EW, December 2024, p. 101) and study the learning-reinforcement questions at the end of the article.

- To receive **one hour (0.1 CEU)** of continuing-education credit, answer the assessment examination questions found below online at elevatorbooks.com or fill out the ELEVATOR WORLD Continuing Education reporting form found overleaf and submit by mail with payment.
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1. What tools are a must for hydraulic elevator diagnosis?
   a. Tachometer
   b. Pressure gauge with fittings
   c. Stopwatch
   d. All the above

2. When is the heat built up in the hydraulic elevator system?
   a. During peak usage
   b. During recirculation through the control valve back to the tank
   c. During high speed
   d. When fully loaded

3. What is the most overlooked factor when adjusting hydraulic elevator systems?
   a. Minimum oil temperature
   b. High speed
   c. Maximum load
   d. All the above

4. Most heat problems will be solved by
   a. Setting slowdown distance to the minimum recommended.
   b. Adding an oil cooler.
   c. Adjusting the valve to a short upleveling distance at the minimum temperature.
   d. a & c

5. What is the best cooling method?
   a. Oil cooler
   b. A/C requirement.
   c. Exhausting the hot air from the machine room
   d. Installing small 5V fan

6. Where are most pressure issues found?
   a. In the up direction
   b. In the down direction
   c. At high temperatures
   d. With heavy cars

7. If pressure drops too far, what happens?
   a. Internals of the valve become slow.
   b. High speed is reduced.
   c. Transitions become slow.
   d. All the above

8. What component does not contribute to pressure drop?
   a. Packing
   b. Oil viscosity
   c. Elbows
   d. Ball valves

9. What is the first line of defense for preventing contamination?
   a. Filter system
   b. New equipment
   c. The cleanliness of the components
   d. A clean machine room

10. When new oil is placed in an old system,
    a. No maintenance is needed for five years.
    b. It is suggested that the oil be filtered again after use to remove dislodged contaminants.
    c. Filtration is not needed.
    d. Contaminants are no longer present.

ELEVATOR WORLD Continuing Education Reporting Form

Article title: **"Hydraulic Elevator Systems – Reducing Common Failures"** (EW, December 2024, p. 101)

Continuing-education credit: This article will earn you one contact hour (0.1 CEU) of elevator-industry continuing-education credit.

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This article is rated for one contact hour of continuing-education credit. Certification regulations require that we verify actual study time with all program participants. Please answer the below question.

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hours: ________________ minutes: _______________

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3.	a	b	c	d	8.	a	b	c	d
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