CHECKER
FOR ELEVATOR SYSTEMS

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ABSTRACT

This paper begins with a brief description and evaluation of why a system for travel comfort was developed. It then presents a theoretical background of how the system works, and the results, which can be achieved by the Checker. Following this, practical measured data for different lifts and suggestions on how to interpret the results in order to improve travelling comfort of hydraulic and traction lifts together with a summary of the Checker´s advantages will be given.

1. INTRODUCTION

The requirements according product liability and responsibility of the producer are becoming more and more important. This means that both the installer of the lift and the servicing staff have to prove that they fulfil the requirements and to document this.
The Lift Directive 95/16/EC and also the DIN EN 13015 „Maintenance instructions for lifts and escalators“ are representing this trend. The „Lift Checker Software“ is a computer-aided measuring-, recording and evaluation system for analyzing lift systems.
For the exact measurement of deceleration and acceleration the „Travel Data Sensor“ with a sampling rate up to 5000Hz is used. In addition, an electronic „Pressure Sensor“ is available to measure the pressure in hydraulic lift installations.

2. FUNCTION OF LIFT CHECKER SYSTEM

2.1 Travel Data Sensor

The Travel Data Sensor was developed to measure and record the exact deceleration curve on each lift directly (valid for traction drive and hydraulic lifts). The travel data sensor is a stand-alone, microprocessor based measuring device with a built in acceleration sensor. The sensor measures in the vertical direction at a minimal lateral sensivity. It is attached directly to the floor plate which ensures that any vibration is measured by the sensor directly. The sensor has a piezo capacity design which makes it able to withstand overload currents. The 10 g-sensor is shock-proof up to 1000 g. The Travel Data Sensor has a maximum resolution of 12 bit which gives a resolution of app. 0.005 g for the entire measuring range from –10.2 g to 10.2 g. For the safety gear test only the –10 g range and 8 bit resolution are used. In this case we have a resolution of 0.04 g.

After the Travel Data Sensor has been switched on an internal memory test is conducted and the real-time clock is activated. The travel data sensor then measures acceleration in the normal direction and stores this value (if the sensor is laid flat this means that the sensor measures the standard acceleration due to gravity = 1 g). Then measurements begin in accordance with the defined parameters and the results are stored in a ring memory.
Data transfer between the Travel Data Sensor and PC occurs via the serial interface (COM1/COM2) with the aid of the serial-cable.

2.2 Pressure Sensor

An electronic Pressure Sensor has been specially developed to measure the pressure in hydraulic lift installations. This sensor operates in accordance with the thin film measuring principle. The sensor is housed in a protection type IP65 sealed stainless steel housing and is equipped with a ¼" pressure take off. It is sealed by means of an integrated O-ring. Alternatively it is also possible to connect it using an express coupling. The standard measuring range is up to 100 bar with a resolution of 0,02 bar.
The pressure sensor and the Lift Checker Software can record the oil pressure curve as a function of time p = f (t).

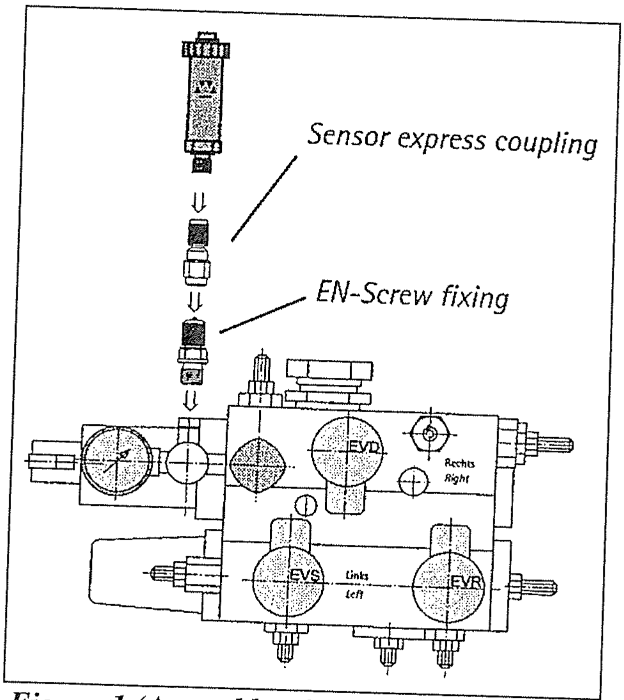

Figure 1 (Assembly of the Pressure Sensor)

During measurement the readings are transmitted online to the PC. There memory is allocated for 16.320 readings. Recording can be performed either at a measurement rate of 100 or 10 Hz. Thus one can choose between recording periods of slightly less then 3 and of more than 27 minutes. When measuring at a rate of 100 Hz each individual reading will be recorded, at the 10 Hz measurement rate the mean value of 10 readings will be recorded.
Assembly of the sensor can be done easily. The content of supply includes different kinds of screw fixing so you can install the sensor on all hydraulic aggregates and valve blocks respectively.
Figure 1 shows the principle installation of the pressure sensor at valve block from OMAR Lift.

2.3 Lift Checker Software

The measured values can be shown as a diagram on the screen, evaluated, stored and printed. The print of the diagrams complete the existing documentation of the lift. If you have an IBM compatible computer system using MS-DOS (minimum configuration 8086 processor, 500kB free RAM memory), the software can be installed and used easily.
Measurement protocols can be archived and administered by using Liftcalc®
(Product management software with included data base for handling of order related data).

3. OPERATING RANGE OF LIFT CHECKER SYSTEM

3.1 Travel Data Sensor

3.1.1 Measurement of travel quality

Previously travel quality could be evaluated on a subjective basis only. Now it is possible to measure the deceleration and acceleration values in a travel cycle and display these as a diagram on the screen. The following figure 2 is a schematic example of travelling between floors in the upward direction.

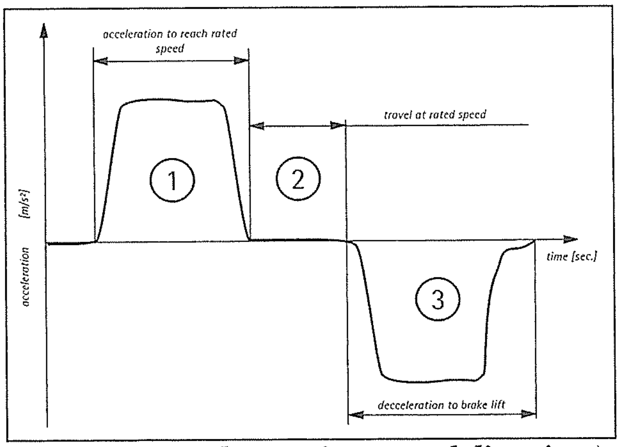

Figure 2 (Travel curve in upward direction)

The diagram can be evaluated according to the following criteria:

- effective acceleration to reach the rated speed
- effective deceleration to slow down the lift after the rated speed has been reached
- optimization of the travel curve when the motor control is activated
- estimation of the time it takes for a travel cycle
- depiction of oscillations and vibrations in the direction of travel (e.g. lift jams) and perpendicular to the direction of travel (e.g. poor guide rail transition).

Evaluation of the deceleration diagram can be done by using the keys of the PC which set or move the flags. The screen shows both average deceleration and time difference between the two limits. The following pictures show a few examples of how to make an evaluation.
Figure 3 shows the phase of acceleration up to the rated speed. In this case limits are set so that you can get the value of average acceleration (Ø ½ = 0,49 [m/sec²]).

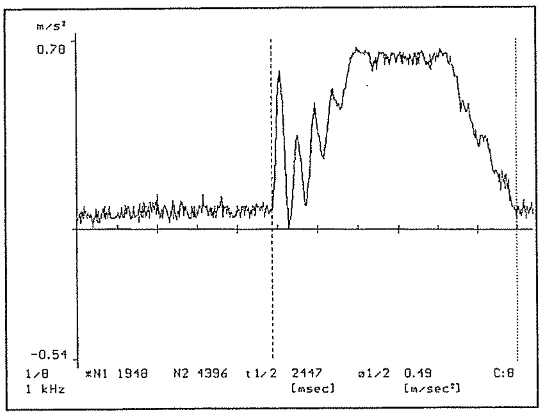

Figure 3 (Average acceleration)

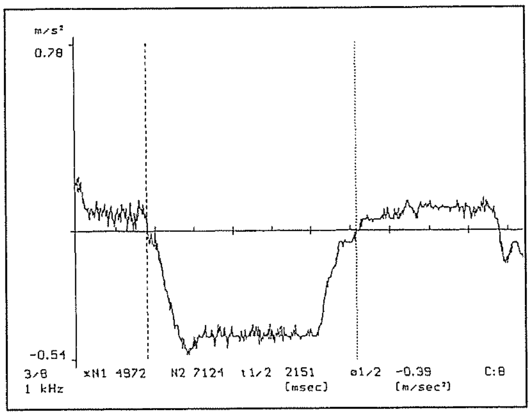

Figure 4 (Deceleration of car)

In figure 4 you can see the process of deceleration of the lift car. In this case the average value for deceleration is Ø ½ = -0,39 [m/sec²].

The deceleration diagrams and the travel curve respectively are effective tools for adjusting motor regulators. Make certain that acceleration is set to maximum to reduce the duration of travel cycle and to increase hoisting capacity respectively. Figure 5 shows an irregular travel curve with rough performance during deceleration and stopping. In figure 6 you can see smooth acceleration and deceleration, oscillating during travel at rated speed and slight jerk during stopping.

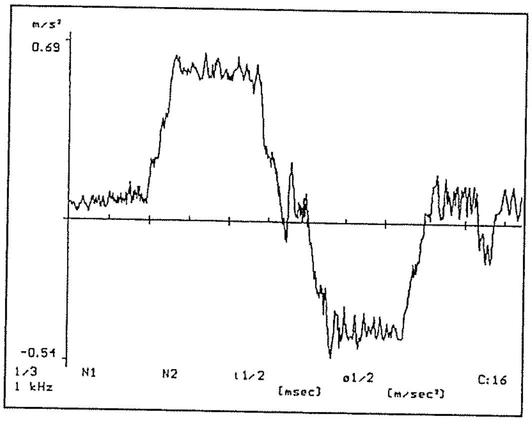

Figure 5 (Irregular travel curve)

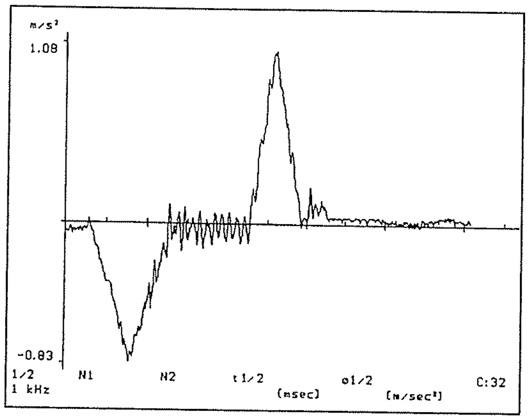

Figure 6 (Smooth acceleration)

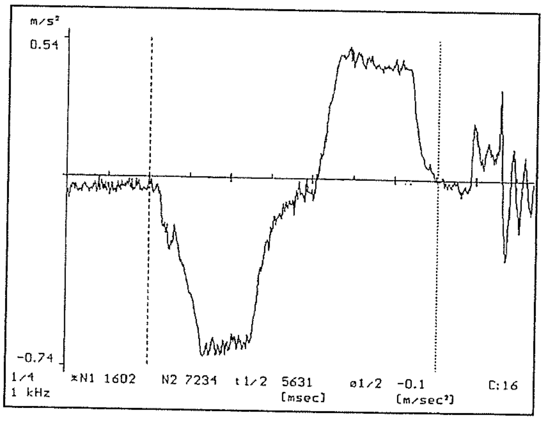

Figure 7 (Travel cycle)

Another possibility for evaluating deceleration diagrams is to determine the duration of a travel cycle (see figure 7).

The duration of the travel cycle results in

t 1/2= 5631msec = 5,63 sec

3.1.2 Deceleration safety gear

The safety gear is an essential component in any lift. It is important that this equipment be subjected to regular tests to check that it functions properly.
During the safety gear test the safety gear generates braking power on the rails which depends only on constant parameters i.e. the preset elastic forces for the safety gear and the materials of brake shoe and rail. This makes it possible to calculate deceleration of the loaded lift car. Deceleration depends only on the ratio of lift car mass to lift car mass plus rated load. If the safety gear is adjusted correctly, deceleration of an empty lift car is always higher than 1 g. This causes the counterweight to jump which means that only the lift car mass has effect on the safety gear. This moment ("Lift car without influence of counterweight") is based on the evaluation of the measured values and is analogous to the conditions present during the free fall of the lift car.

The result of the safety gear test makes it possible to state whether the lift car (loaded to the rated load) would be decelerated during the free fall within the permissible limits.
This ensures that the lift will be braked safely in any situation less hazardous than free fall (load < rated load or no free fall). The travel data sensor is particularly suited for recording safety gear tests on an empty lift at speeds which do not exceed 2 m/s. As it is not possible to exclude the possibility that the safety gear will activate with an empty lift car in standard operation, it must be assumed that a lift is able to withstand the stress which occurs during this test.

The safety gear test is a quality control measure and should be conducted by lift operating companies on a regular basis. However, evaluation of safety gear with the aid of the lift checker or travel data sensor is not a substitute for official inspection tests conducted by an expert appointed by a notified body (e.g. TÜV). Further it is necessary to do the first inspection with 125% overload in order to test all the mechanical parts of the lift.

For a better understanding, a calculated speed curve can in addition be superimposed on the deceleration curve in the diagram. The speed makes it easier to set the limits for the start and the end of the safety gear test. Figure 8 shows a typical safety gear test diagram.
As soon as both limits are set, two characteristic deceleration values appear on the screen. The value $a_{measure}$ indicates the average deceleration measured for the empty car between both limits. The figure a_{loaded} is the value calculated for the car loaded with rated load, in the case of free fall. To fulfil the requirements of the applicable technical regulations this value must remain within the following limits:

TRA: 0,2 ... 1,4g
EN81: 0,2 ... 1,0g

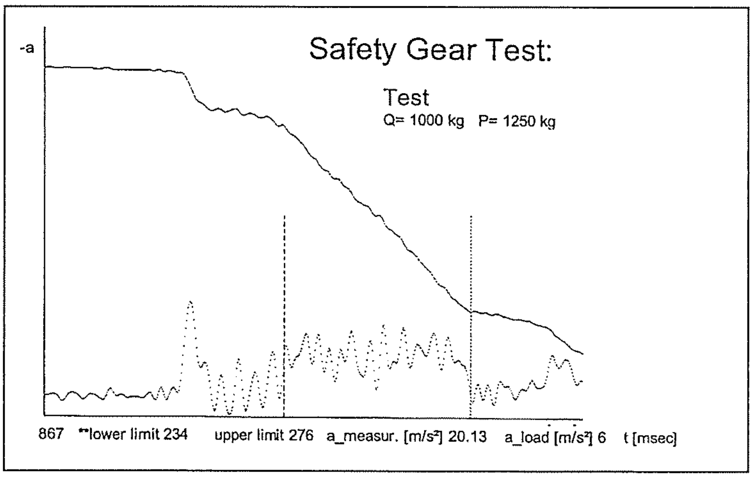

Figure 8 (Safety gear test)

The diagram above was recorded on a lift with excentric wheel type safety gear. The test result shows an upper limit at 276 msec and a lower limit at 234 msec. That means a safety gear stopping time of

$$t_{stop} = (276 - 234)\ ms = 42\ ms$$

The actually measured safety gear deceleration of the empty car is 20 m/s² = 2 g. For the free fall with the rated load the deceleration is calculated to be 6 m/s² = 0,6 g.
This means that the TRA and the EN81 requirements have been fulfilled.

3.2 Pressure Sensor

3.2.1 Pressure Measurement

If pressure is recorded as a function p = f(t) during the travel cycle of an empty lift car, a pressure curve similar to that shown in the following diagram (figure 9) is produced.

There is always a clear difference in pressure between the up run and the down run.
This difference in pressure results from internal losses to different system components, particulary due to:

- friction between the guides and rails
- friction between jack and sleeve
- other system inherent losses

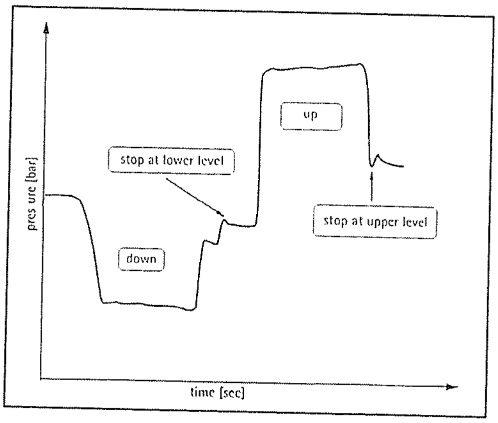

Figure 9 (Pressure curve)

Friction between the guide and rails is largely unrelated to lift car load where a centre lift car strut is used. Jack friction is also largely unrelated to the lift car load. On the other hand internal system losses occur which increase as pressure increases.
The following pictures show some examples of how to do an evaluation.

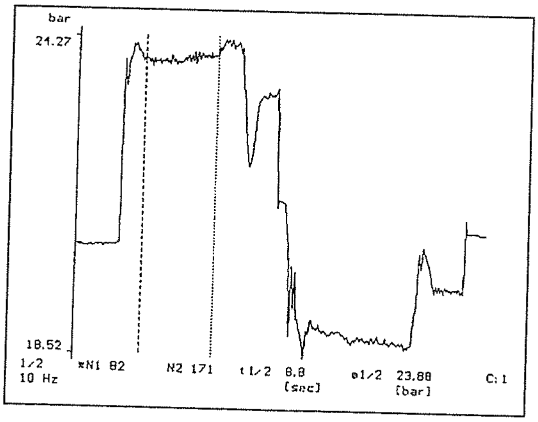

Figure 10 (Up and down run)

The curve (Figure 10) at left shows an up run and a down run. The up run is nearly ideal. A jolt can be detected at the transition point between acceleration and downward movement at rated speed. Creepage is different in length for upward and downward directions. In this curve an average constant pressure of 23.88 [bar] was attained in the upward direction over an interval of t1/2 = 8.8 [sec].

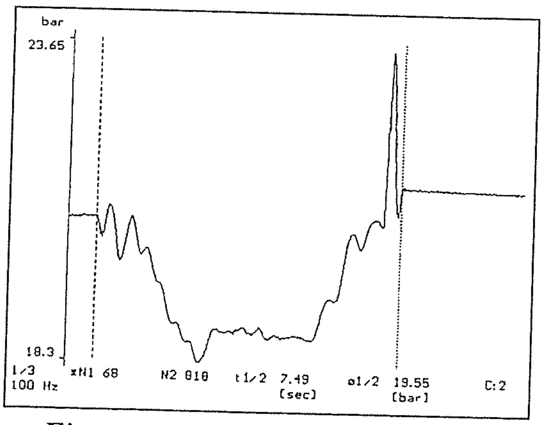

Figure 11 (Oscillating drive)

This curve (Figure 11) shows a down run with clearly visible oscillation and excessive jolting at stops. This diagram shows the interval for the down run. The time equals tl/2 = 7.49 [sec].

3.2.2 Check Anti creep device

The program uses the recorded pressure loss functions for constant down run / up run for an empty lift to calculate whether the device readjusts at the rated load. Important for further calculation is factor Kdyn. Kdyn equals pressure P2 divided by the static pressure.
Factor Kuev is also identified in the diagram. Kuev equals the actual over pressure measured when the shut-off valve is closed divided by the static pressure.
These two factors should be compared as the result of the relevelling test. If the equation

$$Kuev > Kdyn$$

holds true the anti-creep device will operate correctly and is able to readjust the lift car loaded with the rated load.

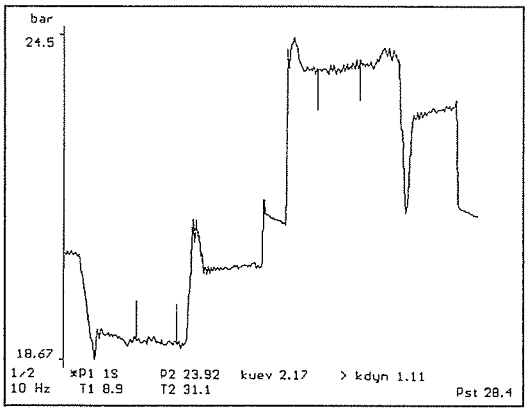

Figure 12 (Anti-creep-test)

The anti-creep device test is a quality control measure and should be conducted by lift operating companies on a regular basis. The typical example shown in figure 12 on the left side fulfils these requirements. The continuous differences in pressure during down run and up run are derived from the corresponding effective height of the jack oil column. According to definition the highlighted ranges were generated automatically at the termination of the down run and up run respectively.

This system would be able to readjust the lift car loaded at the rated load as the required condition kuev > kdyn is fulfilled.
The static pressure for the lift cab at the rated load equals Pst = 28.4 [bar].
The system ID number will be included on the printout. For documentation purposes we recommend you to make a data printout which includes the full measurement and system parameters.

3.2.3 Adjustment of pressure rupture valve

For the setting procedure of the pressure rupture valve, the actual system pressure (stationary valve opening pressure) of the valve is displayed on the screen. By means of the static rated pressure the standard setting will be computed (limited to 140% of static pressure according to TRA 229.13, EN 81-2 Par. 12.5.3) and displayed in an information window.

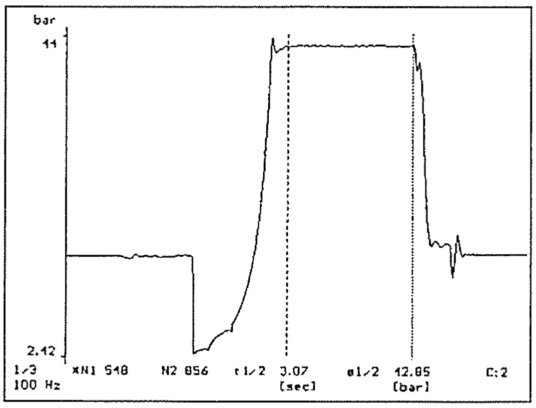

Figure 13 (Pressure rupture valve)

At the same time the pressure now measured online will be displayed in a display window.
Now, the setting can be corrected until the target and actual value are the same.

Figure 13 shows activation of a pressure rupture valve on a curve which is nearly ideal. The setting of the pressure rupture valve in this case equals to:

$$ø1/2 = 42.85 \text{ [bar]}.$$

4. SUMMARY OF THE LIFT CHECKER ADVANTAGES

- Proven documentation of the functionality and safety of the lift installation in accordance with Lift Directive 95/16/EC
- Complete documentation of an installation (product liability)
- Weights are not required
- Easy to use

4.1 Travel Data Sensor

- Assessment of the travel quality of traction and hydraulic system
- Trouble-shooting in the system by vibration and oscillation measurements
- Measurement and assessment of critical decelerating values (activation of buffer, electrical emergency stop).
- Data transmission from travel data sensor to PC via serial interface; measurement listings can also be transmitted to a central location by telemetry
- Safety gear check when lift is empty (Adjustments checked in accordance with EN81)
- Assessment of the acceleration and deceleration diagrams using LIFTCALC®
- Sampling frequency 5000Hz
- Acceleration range ±10g
- Shock resistant up to 1000g

4.2 Pressure Sensor

- System pressure check and analysis of possible pressure drops (leakages)
- Examination of the behaviour of the dynamic pressure in the system
- Control system check (e.g. resonance, overshoot)
- Testing of the anti-creep device
- Adjustment of the pressure rupture valve
- Evaluation of the pressure-time diagram through LIFTCALC®
- Max. measuring frequency 100Hz
- Standard measuring range 0...100 bar

5. REFERENCES

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6. BIOGRAPHICAL DETAILS

Mr. Christoph Kressirer got his electronic engineer degree in 1991. Then he was involved in projects regarding motion control. In 1997 he came to the elevator business. Until the end of 1999 he was responsible for electronic products and service. Since January of the year 2000 he has worked for WITTUR AG, where he is also responsible for service and electronic systems especially for drive systems.