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L-Plan Group

On line safety valve testing - Legatest

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The experienced service provider with more than 15 years experience in on line safety valve testing gathered in Germany, Sweden, Slovenia, France, Austria, Finland and India.

Your aim is to ensure safe and reliable operation of process plants. The prerequisite is the proper maintenance and regular testing of their components. Particular care has to be taken of safety critical components such as pressure relief valves.
The conventional approach would involve, shutting the plant down, removing the valves from the plant, testing in the workshop and inspecting, repairing, readjusting, and final testing (whatever necessary).

The alternative is to perform the testing on site & on line - while the plant is operating.

L-PLAN Group has both profound knowledge and technology to do it. Our personnel will either perform the job using LEGATEST - the fully automatic device for on site & on line testing of safety valves, or we will supply the devices and train your staff so that you can perform the testing yourself.

We have provided services, and have been selling the equipment to complex process and energetic systems, such as:
chemical and petrochemical industry, oil refineries, nuclear and fossil power plants, hydroelectric power plants, pharmaceutical industry, food processing industry, gas producers, boiler manufacturers and other…

The principal activity of **L-PLAN Group** is providing complex testing services to its clients
- testing of safety valves,
- maintenance and repairing of valves,
- calibration of pressure and temperature sensors
- supply of valves and related spare parts

To provide these services, **L-PLAN Group** implements the technology and devices which are the product of its own knowledge and experience.

1. TESTING DEVICES

Legatest - the equipment used for testing of safety valves represents the "state of the art" of mobile devices for testing and calibration, and is operated by highly motivated, well trained and experienced staff.

In 1992, as predecessor of LEGATEST, our first electronic data acquisition device named LEGALINE was developed.

It was used for conventional testing of safety valves as well as pressure and temperature sensor calibration.

While implementing this new technology we have acquired confidence and recognition from surveillance and inspection authorities.

The benefits were: increased accuracy and reliability of testing result, reduction in maintenance duration and cost and last but not least reduction of harmful emissions to the environment.

Based on practical experience gathered while providing testing and calibration services, 1995 the device for on line testing of safety valves called LEGATEST was developed.

2. CONVENTIONAL TESTING

Conventional safety valve testing involves:

- ⇨ testing on test bench in a workshop
- ⇨ testing with water or air (similar media)
- ⇨ testing at room temperature (for valves on high temperature service correction factors have to be taken into account)
- ⇨ dismantling of valve necessary → cost
- ⇨ shutdown necessary → production loss due to shutdown

While testing conventionally:

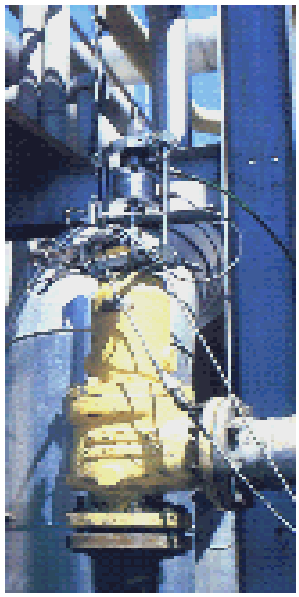
- pop up pressure is determined as pressure at the instant we have heard the air started to flow
- or as the peak pressure we have recorded during testing

We have an **indirect indication** that the valve should have opened while being tested based on our experience. However we do not have a **direct positive proof.**

3. WHY "ON-LINE" SAFETY VALVE TESTING?

Because it has numerous advantages compared to of line (conventional testing):

- Testing is preformed in real operating conditions: temperature, working media, system accumulation, so that accuracy of testing results is high.
- Testing with Legatest reduces production loss and fuel cost. Since it is not necessary to raise system pressure the plant lifetime is extended due to reduced material stress.
- By performing the testing without removing valves from the plant we save time and money. Maintenance of valves on heavily accessible and remote locations becomes easier.
- Welded in valves can be adjusted without removal from the line, so the cost for cutting these out and subsequent welding and weld inspections are avoided.
- Damage like valve seat erosion is considerably reduced.
- Legatest improves the environmental conditions by:
  - ⇨ Reducing noise levels.
  - ⇨ Reducing fuel consumption.
- Surveillance and inspection authorities recognize the results obtained. This confidence is demonstrated in the TÜV certificate issued for the LEGATEST system. **The results are reproducible and can not be manipulated.** The reports generated contain all the relevant input data, test results and the respective diagrams, testing time and date.



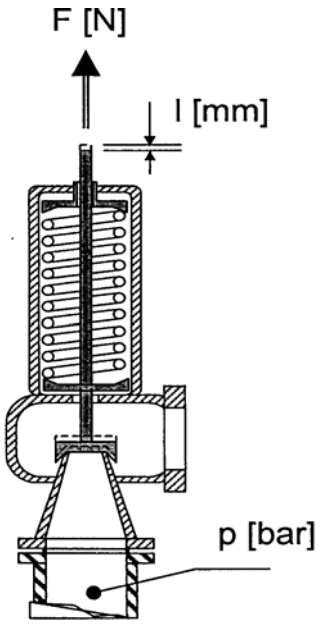
4. HISTORY

The idea of on line valve testing started in the late forties of the last century.

The logic behind this procedure was as follows:
The most realistic safety valve test can be made by **raising the system** pressure in the plant up to the value at which the safety valve starts popping up. The consequence would be:

- that **all the plant components** would be exposed to the **excessive loads** leading to **reduced operating lifetime**.
- the normal operation of the plant would be interrupted
- such test method involves a lot of personnel and equipment since all the safety valves are tested at once

If we are able to **replace the force** acting on the valve spring due to **additional pressure in the system** with **controlled force pulling the valve spindle** and **determine the force value** at the **moment** when the **disc starts lifting** than we will be **able calculate** the corresponding **pop up pressure.**



5. HOW DOES LEGATEST OPERATE?

Legatest opens the valve slightly by pulling the spindle. Force, pressure and lift sensors are sending signals to electronic data acquisition and test control unit. After the testing procedure we determine the opening point. The system calculates and displays the results.

On LCD the different graphs for each parameter (pressure, force and lift) are shown.
At the set pressure point the valve disc and spring start to move. The valve opens and the excess system pressure can escape. This characteristic position in the graphs (diagrams) is marked with linear cursor
and the set pressure is calculated in real time.

With LEGATEST following tests on safety valves can be performed:

- While the system is operating – HOT TEST or
- While system has been shut down – COLD TEST

When testing with Legatest we record the values of three parameters in given interval of time to obtain three curves:

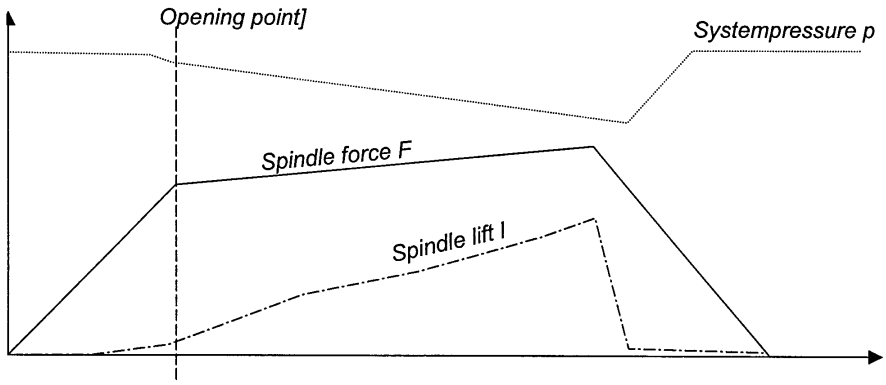
- displacement of valve spindle versus time
- system pressure versus time
- pulling force versus time

The indication of:

- effect of the nozzle ring
- effect of the guide ring
- reseat pressure of the valve

is also possible.

To simplify the determination of opening point the acoustic signal can be recorded and the respective curve evaluated as well.



As indicated in the introduction the curves have a **characteristic point** where their **gradient abruptly changes at the same time** - at the **moment when the valve starts popping up** (see the schematic diagram enclosed).
The spring stars to move not only due to the additional pulling force but due to the pressure of the medium as well → the **gradient** of the **force** curve **changes abruptly** (there is a sharp bend in the curve)
The disc (spindle) lifts → the **gradient** of the **lift** curve **changes abruptly.**

The valve opens → the medium escapes from the system → the system pressure falls→the **gradient** of the **pressure** curve **changes abruptly.**

If relevant the **value of backpressure** can be simultaneously recorded as well.

When these curves are available this **characteristic point** can be **identified** – thus the **pop up pressure determined**.

The valve opening is associated with distinctive acoustic phenomena which are recorded as well.

In this case, we would be **in principle being able** to determine the pop up pressure based on only **one of those parameters** (in the **conventional tests** we determine it **based on pressure only**).

However we use **three parameters in „warm test“** - or „**two in cold test“**
(system pressure = 0) → result is higher accuracy

Since we record the displacement we have a **direct positive proof that the valve spindle / disc have moved.**

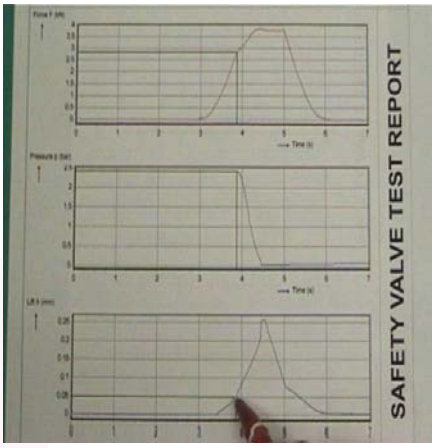
$$P_{open} = P_{system} + \frac{F}{A_{seat}}$$

Which component of the valve is actually tested when we determine the pop up pressure of the safety valve?

The spring.

Why?

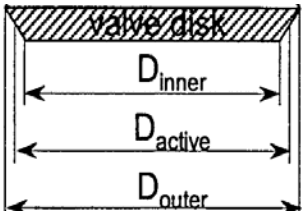
Because with time due to corrosion and / or high temperature its characteristic may deteriorate.



6. LIMITATIONS AND HOW TO OVERCOME THESE

In some cases it is not possible to get correct information of middle sealing diameter or active surface of valve disc on seat.

When analyzing the formula we note that the value of ***A seat,*** necessary to perform the calculation is not determined by the measurement – thus has to be either known from the valve documentation or determined some other way.
Accuracy of the value of ***A seat,*** necessary may have a great impact on the accuracy of the value of the pop up pressure determined by calculation / measurement.



The most common approach is to presume that the active valve disc diameter (which is the basis for the value ***Aseat)*** is equal to the average of the inner and the outer valve disc diameter.
Obviously the real active valve disc diameter may be different, thus an error may occur.
The smaller the disc diameter is, the more significant the difference may be.

Sometimes the geometrical data on the (particular) valve are available in the technical documentation or have been measured and recorded in the course of previous maintenance activities. However it should be noted that these were measured at room temperature and that the values at working temperature (at which the testing is performed) may be significantly different.

Being aware of those limitations the error introduced in the measurement can be calculated and the check performed weather the accuracy of results obtained in the particular case satisfies the requirements of the applicable regulations & service conditions.

However there is a way to overcome these accuracy limitations.

Legatest offers the solution to the problem.
It is possible to determine the value of active valve disc diameter of the particular valve at working temperature by performing two measurements at two different pressures in the system.

$$P_{open} = P_{sys1} + \frac{F_1}{A_{seat}}$$

$$P_{open} = P_{sys2} + \frac{F_2}{A_{seat}}$$

After solving the system of two equations above for ***Aseat*** the following formula is obtained:

$$A_{seat} = \frac{F_2 - F_1}{P_{sys1} - P_{sys2}}$$

The LEGATEST device has a function which performs this calculation and determines the **actual value of active valve disc diameter of the valve being tested.**

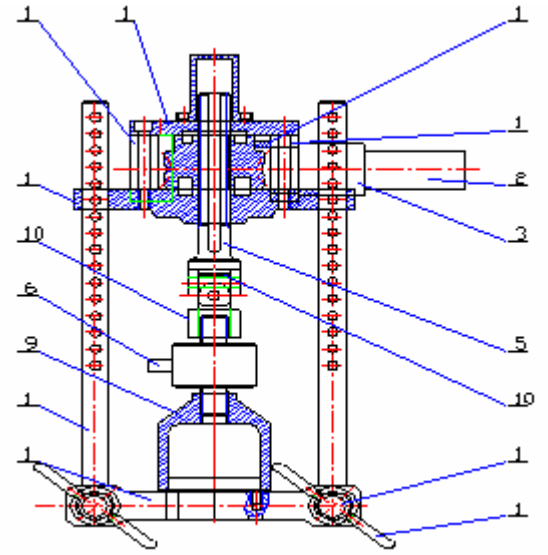
This way the error introduced into the measurement due to uncertainty of the value of the active valve disc diameter is eliminated.

7. LEGATEST TECHNICAL DATA

LEGATEST consists of two main assemblies:

The first one is the CONSTRUCTION comprising:

- EEx proof electric motor housing
- Planetary reduction gearing,
- Worm gear,
- Moving lift screw,
- EEx force sensor
- EEx pressure sensor
- Acoustic sensor
- Sensor of the lift,
- Clamping head,
- Gimbals.



The second one is ELECTRONIC SYSTEM situated in the same housing as motor comprising:

- Highly accurate AD converters
- Motor controller
- Rechargeable battery
- Processor unit
- Main switch for ON/OFF
- Connectors and sockets

- Printer
- Custom made tablet PC or conventional laptop

are delivered as separate units.

The device is ready for operation immediately after being switched on.
LEGATEST is controlled via personal computer.
As power source the accumulator built in the motor housing is used.

Connecting the sensors and preparation for testing is fast and simple. For harsh climate, poorly accessible areas and critical safety conditions, LEGATEST standard offers direct remote control on distances up to 200 m or more.
The use of the electric motor drive results in fast response and high testing speed as well as compact construction dimensions.
The rechargeable batteries offer the necessary autonomy and ease of operation.

The maximum pulling force of LEGATEST basic version is 50 KN. Operating temperature range of the electronic components is -20 to 75 degrees Celsius. If these temperature limits are exceeded the device is automatically switched off.

LEGATEST can also be used **in potentially explosive zones. The motor housing is EEx proof .**

- **EEx load cells**
- **EEx pressure sensors**

are included in the scope of delivery.

8. CALIBRATION

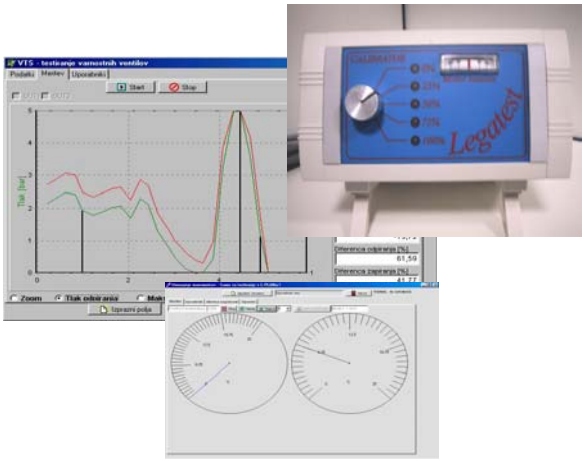
To obtain the high accuracy of measurement, LEGATEST features the internal calibration and accuracy indication of the most important measuring components. With electronic and physical calibrators the following checks are performed:

- ⇨ Zero calibration of force
- ⇨ Internal electronic device indication
- ⇨ External force indication

To enhance the accuracy of the measurements, when switched on the system (LEGATEST) automatically calibrates the sensors to zero.
In addition the force values obtained by sensors and those calculated by power consumption of the motor are compared – thus the accuracy of the force sensor is continuously monitored.

Naturally the force and pressure sensors can be calibrated externally.

Using a special calibrator, LEGATEST can accurately show, if the force sensor is still in tune. While performing a calibration test, LEGATEST draws a diagram with three graphs - force traced by the sensor, force calculated from power consumption of the motor (internal force calibration) and the force calculated from the calibration device.
Using three cursors, the technician can get numeric information about significant diagram points



9. SAFETY

The logic of the in line testing may be simple yet as in the most cases “the devil lies in detail”.
LEGATEST is provided with powerful interface for hardware and software diagnostics.
LEGATEST device is simple in operation and has a number of features designed to prevent the damage to the testing system and to the valve.

Protecting the system

- **sensor overload protection** - the maximum motor force is limited by the force sensor measuring range
- **system overload protection** - the maximum motor pulling force is mechanically limited so that the respective deign values of the components are not exceeded.
- **excessive temperature protection** – temperature is monitored. If the temperature value exceeds the operating limits the system it is automatically shut off.
- **power monitoring** - an electronic system monitors if the supplied current and tension meet the requirements of the electronic components

Protecting the valve

- **valve overload protection** – the maximum force applied to the valve is calculated from the valve data.
- **maximum lift limitation** – the maximum lift of the valve disk can be limited through the valve parameters.

These and other safety features increase the reliability and safety of measurements and are not intended as replacement for qualified and well trained operator.

It is of utmost importance that the personnel operating the equipment have the profound knowledge of safety valves, the test method and the equipment used. It should be also aware of the risk that may be associated with such testing in order to be able to avoid it.

10. SOFTWARE AND DATA BASE

The data of each valve and its related test can be stored in a database. If a valve is tested again, the existing data can be uploaded.

LEGATEST is controlled / operated directly from personal computer.
For each test run the measurement uncertainty is automatically calculated. Thus the full control over quality of the results obtained is available.

Report printing
A customized test report may be printed immediately after testing or later, whichever desired.

11. LEGATEST APPROVALS AND CERTIFICATIONS

Legatest is a proven and the reliable system for in line testing of safety valves. It is:

- Recognized by surveillance authorities such as German TÜV.
- ATEX risk analysis - approval from TÜV Germany.
- Technical instruction for Testing of Function of safety valves using LEGATEST, made by DNV - Det Norske Inspection.

12. ON SITE SAFETY VALVES TESTING PROTOCOL

On each location where safety valve has to be tested the following has to be done:

- Location and accessibility of safety valve determined.
- Visual examination of safety valve
- Assessment of mounting possibility
- Determination of ambient temperature, presence of any dangerous or explosive media.
- Possibility of enhancing security on testing location.

All the safety measures for the realization of testing have to be implemented (as prescribed by the law and internal plant operators regulations).

For correct and safe testing the following should be examined:

- existing documentation on safety valve
- existing documentation on the system which is protected by the safety valve

After examining all the technical characteristics we can begin preparing the valve and mount the LEGATEST device in following order:

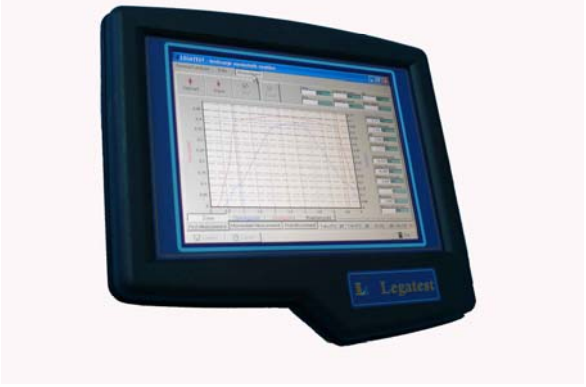
- Removing the seals – only those which are not allowing to perform the testing
- Carefully removing the cap of safety valve
- Placing Legatest on safety valve

The operation of LEGATEST is controlled from PC which must be connected to the motor housing by a single cable.

If the testing is performed while the system is in operation we should either replace one of the existing pressure gauges with a pressure sensor or we should enter into LEGATEST the current value of pressure in the system.
All the commands and data are entered via personal computer.

If for any reason the communication with the personal computer would be interrupted the processor unit in the motor housing would stop the test and return the valve to the initial position.

Force sensor is chosen according to data, calculated by system after the values of the middle seat area and set pressure of valve have been entered.



By pressing button START testing sequence will be started and construction motor begins to move. When construction starts to strain, increase of force and lift can be observed. When valve opens, the pressure in the system starts to fall. On right side of display we can observe the numeric values of all parameters in every instant of time.

When valve opens, force increase is less intense and pressure falls. Lift increases faster. A few seconds later we press the button START again, moving screw starts to move downwards so that complete construction is unloaded. When parameters of force and lift are 0 we stop the motor by pressing STOP.

Three diagrams (four if we use the acoustic sensor) are seen on display. Opening point of safety valve can be determined easily by positioning the linear cursor at the characteristic spot of the curves recorded.
Report can be printed immediately comprising all relevant technical data, results and diagrams.
The data gathered and the test results are stored in the database.

13. CONCLUSION

In line safety valve testing

To ensure safe and reliable operation of process plants their components have to be properly maintained and tested regularly. Particular care has to be taken of safety critical components such as pressure relief valves.

The conventional approach would involve removing these from the plant, testing in the workshop and inspecting, repairing, readjusting, and final testing (whatever necessary).

The alternative is to perform the testing on site & on line - while the plant is operating. For this purpose the additional defined force should be exerted on the safety valve spindle to open the valve. While pulling the spindle, the force, spindle lift and system pressure should be recorded and the "opening" point (force) determined. Provided that the force necessary to open the valve, the effective cross-section of valve orifice/disc and the corresponding pressure in the system are known – the popping up / opening pressure can be calculated / determined. Then, if necessary the safety valves can be readjusted and / or repaired on site. The result is considerable reduction in maintenance cost.

To perform this kind of testing the appropriate device has to be available.

Legatest device - Features

Our response is LEGATEST - the fully automatic device for on site & on line testing of safety valves. Since more than 10 years it is regularly used in Germany, Sweden, Slovenia, France, Austria, Finland, India, Italy, Iran, Kuwait, Croatia, Macedonia, BIH...
LEGATEST is a microprocessor controlled system that uses high performance sensors to automatically test safety relief valves to determine the opening pressure / set point. The testing system's design, use of highest quality components and meticulous quality control result in high accuracy and reliability. It is portable and can be used in virtually any plant in the world on almost all kind of safety valves.

The most important features are:

- ⇨ automated testing procedure
- ⇨ electric motor drive for spindle lift
- ⇨ lift force up to 50 kN
- ⇨ multiple safety interlocks to protect the valve and the device from damage
- ⇨ autonomy in operation due to rechargeable batteries
- ⇨ data acquisition system with adjustable sampling rate
- ⇨ storage of test and valve data
- ⇨ up- and down-load of data to / from external data base
- ⇨ interchangeable pressure and force sensors
- ⇨ universal application
- ⇨ manualy & automatically controlled valve reseat
- ⇨ instant report printing
- ⇨ automatic calculation of measurement uncertainty
- ⇨ simple handling and operation

Legatest device - Benefits:

- reduced plant shutdown times
- increased plant availability
- reduced operation and maintenance costs
- improved maintenance & spare parts management

Legatest is a proven and the reliable system for in line testing of safety valves.

The Proposal

We, **L-PLAN Group** can help you to benefit from the advantages of this testing technology.

Depending on your choice:

we may deploy the device and a crew of experienced technicians and will test your safety valves wherever these are whenever you need it,

or we may deliver the device and train your staff to the same level of perfection as our own .

We will be glad to provide you additional information you may need or to demonstrate our equipment in operation at your plant. Please contact:

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LEGATEST - testiranje varnostnih ventilov
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