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Report on the application of a test equipment
LEGATEST for determination of actuation pressure
of direct acting safety valves,
(spring-loaded valves)

Customer: L-PLAN, Zirovnica (Slovenija)

G.-No. 1.2-229/2000 A.-No. 20/ 449 181

This report comprises 8 text pages and 4 annexures.

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Central department Large power plants

For Rueter

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Essen, 04.04.2001

Report

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1. Order

In the order of M/s L-PLAN, Zirovnica (Slovenija) dated 16.01.01, a test equipment, LEGATEST was evaluated for determining the actuation pressure of spring-loaded safety valves at system pressures before the valves of 0 bar to actuation pressure with only spring-loading.

2. Description of test equipment, LEGATEST

Spring-loaded safety valves at pressures below the actuation overpressure (operating overpressure) are lifted over an electrical motor with planetary gearing with the test equipment LEGATEST of M/s L-PLAN.

The overpressure before the safety valve, the lift of safety valve and the tensile force are measured in this test. All three signals are transmitted to a data processing unit (CPU) and recorded.

The draw gear of LEGATEST, to eliminate transverse forces, is connected with the valve spindle by means of a cardan joint. The annexure I/1 and I/2 contains sketches of test equipment.

The "L-PLAN-operating sequence of valve test LEGATEST" is described in Annexure II/1, II/2 and II/3.

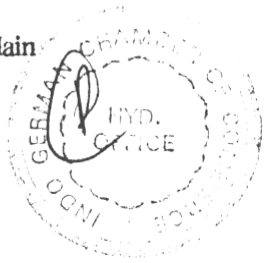
Calibration bars are present for following measuring apparatuses of test equipment:

a) Force transducer

Measuring range	0-1 kN, 0-10 kN and 0-50 kN
Manufacturer	IMT Industrie-Messtechnik GmbH, Frankfurt/Main
Accuracy	± 0.1% of final value
Power output	0 - 20 mA

b) Pressure transducer

Measuring range	0-25 bar, 0-60 bar and 0-100 bar
Manufacturer	IMT Industrie-Messtechnik GmbH, Frankfurt/Main
Accuracy	± 0.5% of final value
Type of protection	IP 65 as per EN 60529 / IEC 529
Power output	4 - 20 mA



c) Displacement transducer

Measuring range	10 mm and 25 mm
Manufacturer	Burster, Gernsbach
Type	8713
Accuracy	± 0.3% (!0 mm) and 0.2 % (25 mm)
Supply voltage	Measuring distance 10 mm: max 14 V
Voltage output	0 - 5 V

d) Central unit (CPU)

Manufacturer	RAMEK d.o.o. RADOVLJIA
	KROVA, Slovenija
Type	LEGA-TEST, Ser.-No. 00296

3. Calibration centers for measuring apparatuses

The force- and pressure transducer must be calibrated annually.

The displacement transducers are calibrated by M/s L-PLAN with gauge blocks.

The calibration of force- and pressure transducers are checked in following calibration centers.

a) Force transducer

Calibration centre : EML Elektriski merilni laboratorij,
(TÜV Cert-ISO 9001)
SI-4244 Pdnart, Slovenija

b) Pressure transducer

Calibration centre LMPS
Fakulteta za Strojnstvo
Laboratorij za Meritve V
Procesnem Strojnistvo
1000 Ljubljana, Slovenija

The central unit "LEGATEST" (CPU) is checked every 2 years by the calibration centre EML Elektriski merilni laboratoriji (TÜV Cert-ISO 9001) SI-4244 Podnart, Slovenija.

4. Three spring-loaded safety valves at different pressures before the safety valves however below the actuation pressure were brought to opening with the test equipment LEGATEST and the actuation pressure was measured with only spring loading.

The test took place on 01.01.2001 at the test bay of M/s Armaturen M. Schuster GmbH, 45711 Datteln.

The technical data of the safety valves are given in the following:

Safety valve

Model	Full-lift safety valve		
Manufacturer	Sempell	Sempell	Leser
Production No.	R 812808/1	501499/1	97.104.56.22/2
Type	VSE 1	VSE 1	431
Nominal width	65/100	150/200	32/32
Component No.	86 - 519	76 - 519	98 - 577
Narrowest valve seat diameter d_o	33.0 mm Ø	80.0 mm Ø	18 mm Ø
Effective seating area	11.116 cm^2	63.002 cm^2	2.96 cm^2
Actuation pressure	70.0 bar	13.0 bar	30.7 bar
Max. lift	8.9 mm	24.8	2.0 mm

Test results

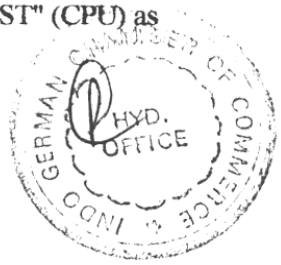
The measured tensile force during the opening of the safety valve is converted in the central unit "LEGATEST" (CPU) as follows as system overpressure, p_2:

$$p_2 = \frac{F, \text{measured}}{A_s \cdot 10} \text{ [bar]}$$

Where

p_2	calculated system pressure from force measurement in bar
F measured	measured force in N at the beginning of the opening of the safety valve
A_s	Seating cross-section

The actuation overpressure of the safety valve is calculated in the central unit "LEGATEST" (CPU) as follows and recorded.



$P_{Actuation} = P_1 + P_2$ [bar]

Where

$P_{Actuation}$	Actuation overpressure of safety valve in bar
P_1	System overpressure before the safety valve during actuation in bar
P_2	Calculated system pressure from the force measurement (see top) in bar

All experimental results of the test at the three safety valves are given as follows in Annexure III:

Annexure No.	Safety valve
III/1	Sempell, Production No. R 812808/1 d_o = 33.0 mm Ø, $P_{actua.}$ 70 bar
III/2	Sempell, Production No. R 501499/1 d_o = 80.0 mm Ø, $P_{actua.}$ 13.0 bar
III/2	Sempell, Production No. 97.10456.22.2 d_o = 18 mm Ø, $P_{actua.}$ 30.7 bar

A measurement report each is given in Annexure IV/1 for the safety valve of Sempell, Production No. R 812808/1 and in Annexure IV/2 , for the safety valve of Leser, Production No. 97.10456.22.2 .

6. Opinion

6.1 General

a) Before each measurement with test equipment "LEGATEST", the maximum lift of the safety valve must be known so that the safety valve does not go beyond this lift under any circumstances and thus causing any damage to the valve.

b) The conversion of electrical measuring signals for force-, pressure and lift measurement in mechanical variables, the recording of actuation point and the calculation of actuation pressure of the safety valve was checked.
The calculation of actuation pressure takes place smoothly. The prerequisite for this is that the data of the above mentioned measuring devises and the effective seating of the safety valve is properly input in the "LEGATEST" (CPU) .

c) In order to obtain reliable results with the test equipment "LEGATEST" the measuring devices and the central unit (CPU) are regularly calibrated and checked, see Pt.3 " calibration centres for measuring devices"

6.2 Accuracy of actuation pressure

The test results show that the actuation pressure can be determined with the help of test equipment for the investigated safety valves (d_o = 18 mm Ø, d_o = 33 mm Ø and d_o = 80 mm Ø) at system pressures of 0 to actuation pressure with "only spring-loaded" with less measuring inaccuracy, only when the effective seating cross-section is know.

The test results can be applied to large valves (d_o > 80 mm Ø) according to our experiences based on in-house measurements at large safety valves.

In case of safety valves, the inaccuracy will increase. In case of safety valves with d_o < 20 mm Ø, a distinctly greater inaccuracy is to be reckoned with.

During the testing of safety valve, d_o = 18 mm Ø (see Annex. III/3), it was determined that the measuring inaccuracy at the pressure before the valve amounts to > 45% of the actuation pressure ± 5%.

It can thus be concluded that with the test equipment LEGATEST for only spring-loaded safety valves d_o > 20 mm Ø:

- the actuation pressure up to system pressures of 0 bar of proportional- and full luift-valves for water, gas and steam can be determined with a measuring inaccuracy of approximately ± 3%, only when the effective seating cross-section of the valves is known

- since the average seating cross-section of safety valves do not correspond with the actual effective seating cross-section, we recommend in case of initial functional test of the valves to determine the actuation pressure "only spring-loaded" and with the test equipment "LEGATEST".

The effective seating cross-section can be determined mathematically with the help of these results.

Under this precondtion, the actuation pressure of the valves can be determined with the test equipment with the same accuracy during in-service tests, as if the actuation pressure of the valves were determined at a test stand (e.g. with steam or water).

Hereby, the measuring apparatuses must be regularly calibrated and the testing must be carried out with same care as in case of tests described here.

For the contents:

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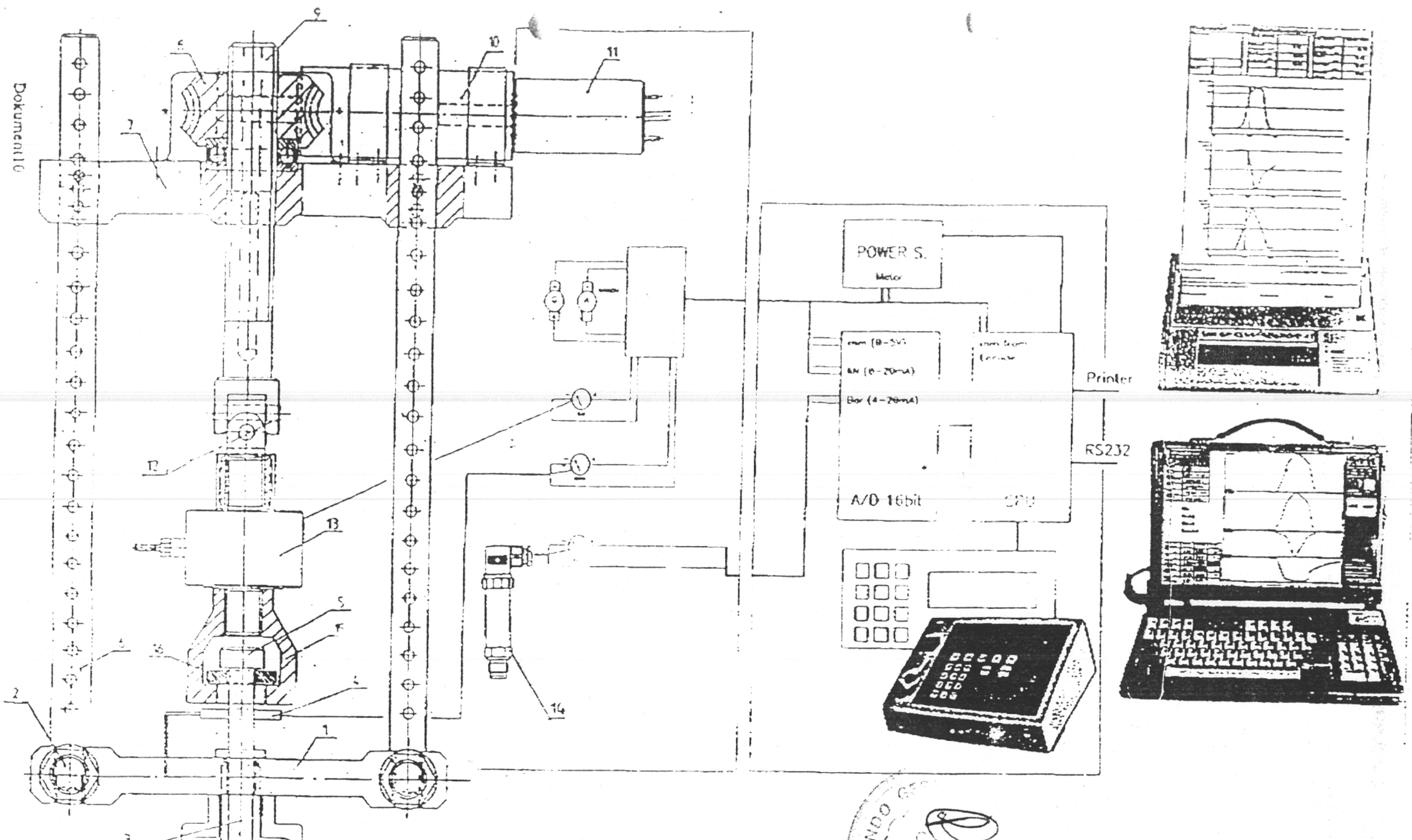
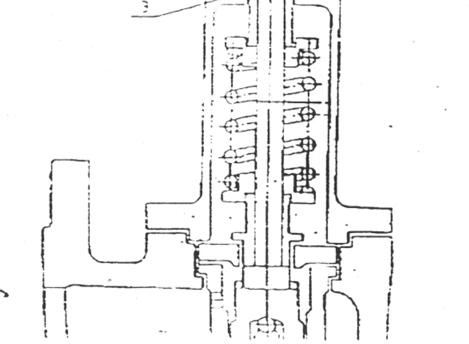
Bernatzki



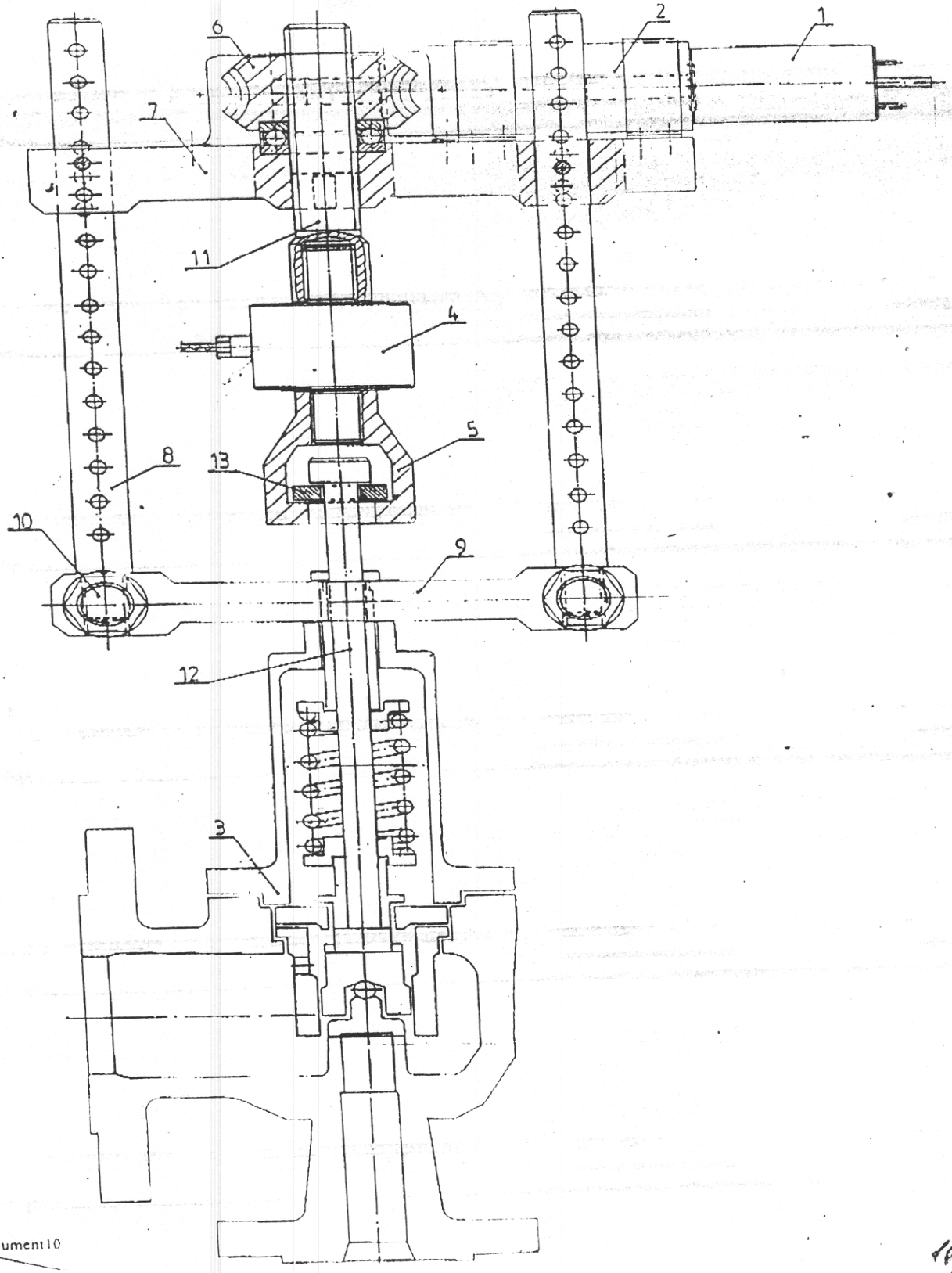


A tensile force is applied in Y+-direction on the valve spindle (Item 3) by means of servomotor (Item 11), the planetary gear (Item 10), worm gear transmission (Item 8) and by means of the stay bar with trapezoidal thread (Item 11). The force is increased till the spring force is overcome in y-direction and the valve responds.
The force applied here is measured by means of a force transducer (Item 13). The valve lift is recorded by means of a valve lift measuring device (Item 4). The system pressure is picked up by means of a pressure sensor (Item 14) at a test manometer connection. All three signals (system pressure, lift, force) are transmitted to a data processing unit and recorded

16	Blocking discs
15	Spindle adapter device
14	Pressure sensor
13	Force transducer
12	Cardan joint
11	Electrical motor
10	Planetary gear
9	Stay rod
8	Transmission: worm, worm gear
7	Top traverse
6	Support- and guide rods
5	Valve spindle head
4	Valve lift meas. -
3	Valve spindle
2	Clamping bolts of fastening plate
1	Bottom fastening plate

10

.9/..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Operation sequence of valve test LEGATEST

1. Disassembly of valve cap

   Disassemble carefully
   Note the locking device for manual operation

2. Selection of matching clamping device

   Depending on the diameter of valve spindle or nut size or split-pin

3. Prepare pressure connection

   Record system pressure at the next-applied manometer
   Selection and assembly of matching pressure gauge

4. Structure of central unit

   Join cable from pressure measuring point with central unit

   Note the cable course (temperature, - gradient)

   Input of valve parameters
   Effective valve surface (cm^2)
   Input desired opening pressure (bar)
   Check whether operating pressure is indicated in display.
   Read the expected max. tensile force (kN) in display

5. Assembly of frame at the valve
   Selection of matching force transducer (depending on max. tensile force)
   Assembly of the frame
   note correct supporting surface
   assemble in the center (2-axes) to spindle axis
   assemble as far as possible low, i.e. near the valve spidle

   Prepare cable joint to the central unit
   note cable course (temperature, - gradient)

   Assembly of distance sensor
   Center to spindle axis
   Do not "tilt"
   Place distance sensor under prestress (insert about 8 - 10 mm)
   Testing of distance sensor (actuate lightly, note the change in display)

6. Data input central unit

   Input of testing technician, valve manufacturer, component number
   Check the desired opening pressure again
   Check the effective valve surface again
   Record the max. expected tensile force
   Select the matching force transducer in display
   Fresh comparison of selected force transducer

Select the matching pressure transducer in display

Comparison of selected pressure transducer display with in-built pressure transducer

Keep frame under prestress

About 20% of expected max. tensile force

7. Test routine

Routine sequence by actuating the test key

Check all read data

- Valve surface
- Desired opening point
- Force sensor
- Pressure sensor

once again.

Before testing, the distance sensor is calibrated by means of a final dimension.

Making the valve respond

Press the start key

Test in display "motor open"

Follow force-travel-pressure line

In case of
- tilting of force line
- Increase of travel line
- If necessary, drop of pressure curve

the opening point is reached.

Depending on the valve size, open the valve further (motor further "on")

Press start-key again (motor "off")
- Drop of force line
- Drop of travel line
- Sometime, rise of pressure curve.

Press stop-key, if 20% prestress is reached.

Place the cursor on opening point

Press enter

A magnification of the curves can be seen

Define the opening point now more accurately.

The criteria for this are:

A) travel curve rise

B) force line drop (in case of full-lift valve and large capacity)

C) pressure drop (in case of less capacity)

Place the cursor at corresponding point and press Enter.

Save the curve and print subsequently.

Match the opening point of the valve to desired value

If it is found that the opening point is outside the tolerance limits of about +/- 5% of desired opening point, the responsible personnel will decide whether a correction of valve should be carried out by loosening the counter nut and subsequently adjusting the spring prestress.

After, if necessary, successful adjustment of spring prestress, Pt. 8.)9.) are followed again till the valve responds in tolerance range.