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Elektronisches Drucküberwachungssystem mit DESY-3
Electronic pressure measuring system DESY-3

ISO 9001 Qualität

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Technische Daten

Elektronisches Drucküberwachungssystem mit DESY-3

• Versorgungsspannung	18-32 V DC
• Genauigkeitsklasse	< 0,4 %
• Schutzart	IP65
• Sicherung	3 x 1,6 A
• einstellbare Druckbereiche	1, 1.6, 2.5, 4, 6, 10, 16 25, 40, 60, 100, 160, 250, 400, 600, 1000 bar
• Schaltpunkteinstellung	0-100% FS
• Rückschaltdifferenz (Hysterese)	0,8-25,9% v. Schaltpunkteinstellung
• max. Leistungsaufnahme	30 W
• zul. Belastung d. Relaisausgänge	150 V DC, 125 V AC, 2 A, 60 V A
• Schaltspiele der Relais	2 x 10^7
• zul. Umgebungstemperatur	0 °C bis +60 °C
• Anschluss	3 x 16-polig, Schraub-Klemmblock 6 x PG9, 3 x PG11, 1 x 5-polig, Anschlussbuchse (opt.) 1 x Erdungsschraube
• Gewicht	ca. 4 kg
• Abmessungen (B x H x T)	ca. 360 x 180 x 90 mm
• Vibrationsbeständigkeit/Schock	Klassifikation n. IEC721
(ortsfester Einsatz, wettergeschützt)	Teil 3-3, Klasse 3M4
(Transport)	Teil 3-2, Klasse 2M1
• Anzeige	3 x 5-stellig/ LED 7-Segment Zeichenhöhe 13 mm, rot 3 x 4 LED's, grün / 3 x 1 LED, gelb / 3 x 1 LED, rot

Technical Data

Electronic pressure measuring system DESY-3

• Supply Voltage	18-32 V DC
• Accuracy class	< 0,4%
• Type of protection	IP65
• Fuse	3 x 1,6 A
• Adjustable pressure measuring ranges	1, 1.6, 2.5, 4, 6, 10, 16 25, 40, 60, 100, 160, 250, 400, 600, 1000 bar
• Switch point setting	0-100% FS
• Return difference (hysteresis)	0,8-25,9% from switch point setting
• max. power consumption	30 W
• permiss. loading of relay outputs	150 V DC, 125 V AC, 2 A, 60 V A
• Relay operating cycles	2 x 10^7
• permiss. ambient temperature	0 °C to +60 °C
• Connection	3 x 16-pole, screw terminal block 6 x PG9, 3 x PG11, 1 x 5-pole connection socket (optimal) 1 x earthing screw
• Weight	approx. 4 kg
• Dimensions (B x W X D)	approx. 360 x 180 x 90 mm
• Vibration and shock resistance	classified to IEC721
(permanent location, weather protected)	section 3-3, class 3M4
(transportation)	section 3-2, class 2M1
• Display	3 x 5-digit / LED 7-segment height of digits 13 mm, red 3 x 4 LED's, green / 3 x 1 LED, amber / 3 x 1 LED, red

Dipl.-Ing.
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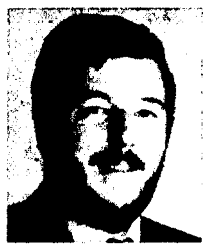

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Electronic Pressure Monitoring for the Control of Valves With Safety-Relevant Task Definition in Accordance With TRD 421 and AD Specifications Sheet A2 DESY-3

By J. Nehring, D. van Well and M. Gladisch

Introduction

The protection of steam boilers and pressure tanks against exceeding permissible pressure levels is accomplished more and more through the use of independently controlled safety valves. Should these valves and fittings also have closed-loop control functions to fulfill, electro-hydraulic actuator systems are utilized.

For the purpose of monitoring the pressure in the installation section to be protected, 3-channel pressure recording systems are utilized which are generally equipped with mechanical pressure switches. The article presented describes problems which can occur when using such pressure switches and the solution to such problems through the application of a newly developed 3-channel pressure recording system "DESY-3" (Druck-Erfassungs-SYstem) based on electronic principles.

In addition, inspection possibilities of the system are described in connection with the hydraulic control system and the resulting advantages for the installation operator.

Components of the New Pressure Protection System

Central Hydraulic Station

The hydraulic station has the following functions:

— hydraulic oil supply of all components and the monitoring of the oil circulation,

— positioning and/or control of cylinders corresponding to specified actuator signals,

— support of functionality inspections of the safety control unit during operation of the installation using stored-programme controller operation (SPC).

Pressure Monitoring

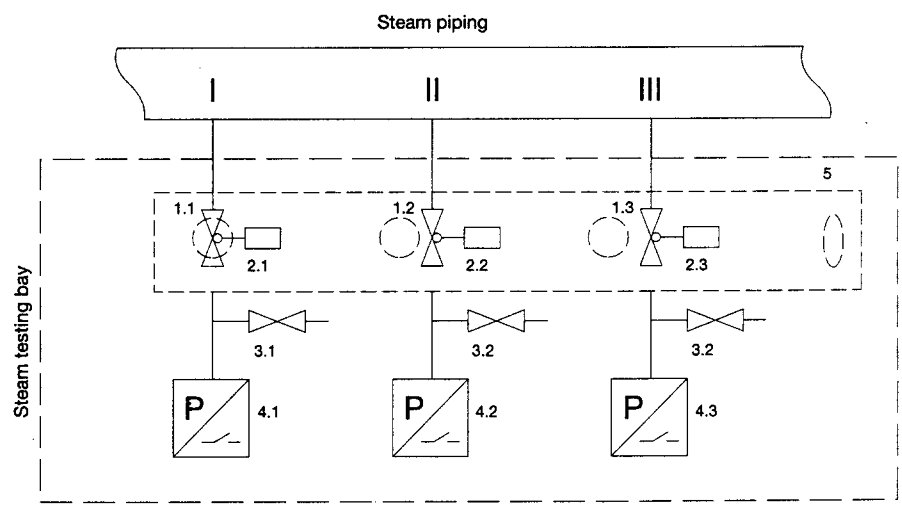
Three pressure switches and/or pressure sensors are located in an equipment cabinet, which are connected to the corresponding individual installation component to be monitored by means of piping lines running out of the cabinet. A mechanical locking system makes it possible to shut off one pressure take-off line for testing purposes while leaving the two remaining lines open for compulsory operation. In this way, testing and adjustment of each pressure switch as well as the total downstream safety equipment can be carried out during normal operation of the installation (Figure 1). This pressure monitoring unit is know under the designation "Steam Testing Device".

Hydraulic Control Units for Safety-Related Pressure Release of the Actuator Cylinders

There are two designs used to implement the hydraulic control units:

— The hydraulic control unit is attached directly to the central hydraulic system, on which the necessary assemblies for control functions and the electric switch cabinet is located.

On application of this design, one or several safety valves as well as pertinent non-safety relevant valves and fittings (e.g. injection valves) can be activated simultaneously or with a common hydraulic control unit. The oil quantity to be controlled for the safety operation is fed to the hydraulic station by actuator cylinders through correspondingly dimensioned piping.



1.1, 1.2, 1.3 HP shut-off valve
2.1, 2.2, 2.3 Terminal switch at HP shut-off valves
3.1, 3.2, 3.3 Shut-off valves
4.1, 4.2, 4.3 Pressure switch (here mechanical)
5 Gate valve

Figure 1. Schematic of pressure monitoring function (steam testing bay) with mechanical pressure switches.

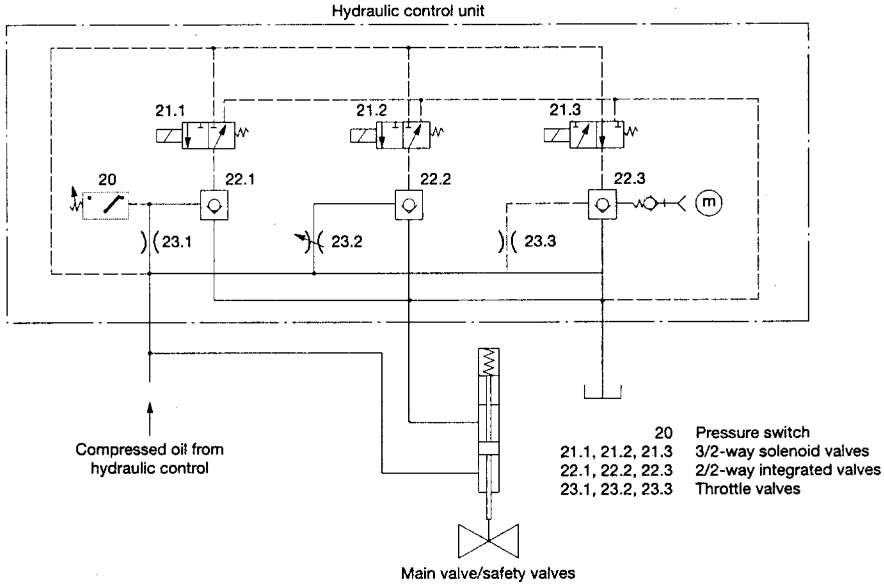


Figure 2. Schematic of hydraulic control unit function (flanged to a cylinder).

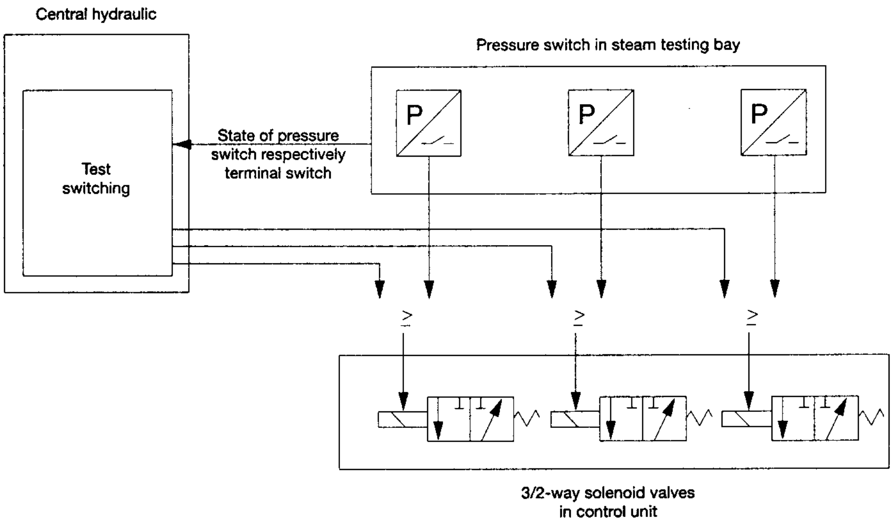


Figure 3. Circuit diagram principle for control of the hydraulic control unit.

— The hydraulic control unit is connected directly to the actuator cylinder by a flange and has influence only on the safety valve (Figure 2). The oil quantity to be controlled is displaced from one cylinder compartment to the other by means of a "hydraulic short-circuit" when the control unit triggers. The advantage here is that the piping lines between the hydraulic station and the actuator cylinders must only be dimensioned for the necessary oil flow for the control operation.

The selection of the most advantageous design in terms of technology and economy is derived from the conditions for application. In principle, the construction is the same.

There are three 2/2-way integrated valves in each hydraulic control unit in arrangement with the three lines in the pressure monitoring system (PMS) which are controlled independently of each other via three solenoid valves.

Each of the individual 2/2-way integrated valves is capable of controlling the required oil quantity from the actuator cylinders necessary for safety functions. The control relief principle applied here assures high actuator power reserves for pickup pressure requirements so that high availability and simultaneously the necessary protection is guaranteed.

Description of Operations of the Safety Function

Each pressure switch and/or pressure sensor in the steam testing bay is assigned to a solenoid valve in the control unit (Figure 3). Triggering the safety function is effected by the three independently-arranged branches in a "1 out of 3" circuit. Should the installation pressure exceed the adjusted value of the triggering pressure, the flow of current to the solenoid valve is interrupted (idle-state principle) respectively is admitted to the valve (actuation principle). All three solenoid valves reduce the load on the corresponding 2/2-way integrated valves. They then open and relieve the load on the hydraulic drive of the safety valve so that they move to their protection position independent of the on-line control commands.

Should the pressure on the pressure switches and/or sensors in the steam testing bay decline below the adjusted triggering point, the main valve goes to the specified open-loop control and/or end position after the triggering of the safety unit. The difference between the triggering pressure and the closing pressure corresponds to the natural hysteresis of the pressure switch or can be adjusted accordingly.

Functionality Testing

The steam testing bay makes possible functional testing of each individual independent control branch during operation of the installation. The test circuit in the central hydraulic system supports exclusively the function test in the specified branch corresponding to the test (see Figure 3). The other two branches are not influenced by these actions and remain fully operational during the test.

The functionality test consists of the following operations:

— monitoring of the functionality of the individual control branches including testing of the solenoid valves and the 2/2-way integrated valves for sufficient actuation power reserves,

— testing of the actuation power at the main valve.

The functionality test of a control branch includes checking for the correct triggering point on the pressure switch and/or pressure sensor assigned to the branch by means of a test pump and the triggering behaviour of the corresponding solenoid valve. This can be visually carried out either via signal lamps and/or by means of the so-called "short stroke" on the main/safety valve. In the case of the "short stroke" the safety valve moves for a short instant (< 1 s) after triggering the pressure switch. The movement is clearly visible in the direction of the safety position and then returns to its previous control and/or end position.

During the test, a residual voltage is applied to the solenoid valves in accordance with the idle-state principle and/or a minimum voltage is applied to the solenoid valves in accordance with the actuation principle. Should the valves show unimpaired operation, it can be assumed that a sufficient amount of actuator force is available.

The 2/2-way integrated valves exhibit controlled movement on being triggered by the applied hydraulic pressure in the actuator cylinder and, as a consequence, have very high actuator force reserves. In addition, testing of the protection unit can be executed at reduced hydraulic pressure (approximately 70 to 80% of the maximum oil pressure). The actuator force at the 2/2-way integrated valves is reduced accordingly so that even in this case proof is provided that sufficiently high actuator force reserves are present.

Reasons for Developing the DESY-3

Until a few years ago, recording of pressures for controlled protection valves and fittings in steam circulatory systems was accomplished almost exclusively by means of mechanical pressure switches. Typical models include Bourdon-tube, piston and/or membrane pressure switches.

In the past, frequent mistriggering of safety devices in various steam-boiler installations occurred as a result of mechanical pressure switches becoming misadjusted. In some instances, the welding of contacts and, as a consequence, the failure of safety devices resulted. Investigations have shown that the malfunctioning of the switches had been primarily the result of applying highly heterogeneous oscillation frequencies to the mechanical components. The source of these disturbances could be traced back to the oscillation frequencies created in steam columns of the piping system itself and/or the surrounding steel structures. If the frequency input in the excitation frequency spectrum corresponds with the inherent natural harmonics of components in pressure switches, malfunctions will likely occur.

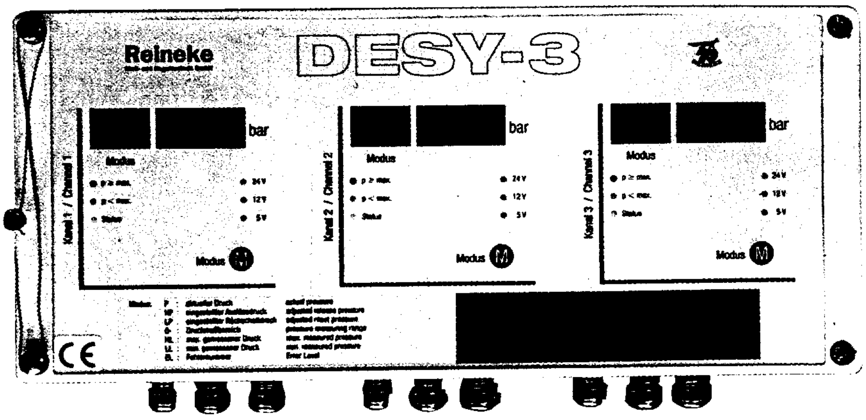


Figure 4. DESY-3.

These problematics were the reason for developing a 3-channel Pressure-Recording System (DESY-3) (Figure 4). The suitability for application in control systems for protection valves and fittings in correspondence with TRD 421 was definitively accelerated by the RWTÜV (Rhenish-Westphalian Technical Inspection Association) in October 1995. Since this time, the DESY-3 has been installed over 30 times in power stations both here and abroad (initial installation in June 1995) and has been operating without failure.

In accordance with the currently valid TRD 421, formal problems exist for the application of electronic equipment controlled by microprocessors in protection valve control systems. It has already been mentioned in [4] that the Committee on "Equipment, Installation and Operational Questions" of the German Steam-Boiler Committee (DDA) has proposed supplements to the TRD 421, in accordance with which equipment controlled either by electronic means or by microprocessors would be certified for use in protection valve control systems if their reliability is shown e.g. within the framework of a component inspection.

This proposal has in the meantime been passed by the General Committee of the DDA so that the TRD 421 can now be amended correspondingly.

Construction of the DESY-3

In accordance with the TRD 421, the DESY-3 has a 3-channel design, each individual channel being designed identically (Figure 5).

The channels have a purely electronic design and are based on a microprocessor supported circuit. The connection to the system to be monitored is carried out via an externally connected pressure transformer. By means of the coding switch installed in the DESY-3, allocation is made possible for 14 different measurement ranges covering the pressure range from 0 to 400 bar. In addition, the response pressure and the closing pressure as well as operation in accordance with the idle-state and/or activation-state principles can be adjusted by means of a switch.

Each channel is assigned an indicator which makes it possible for the operator to call up a multitude of data such as for example:

— indication of the actual pressure,

— indication of the triggering pressure set,

— indication of the adjusted release pressure (hysteresis),

— indication of the pressure measurement range corresponding to the pressure tranformer,

— maximum-value memory,

— minimum-value memory,

— indication of error tolerances.

Defect Recognition

All channels are interconnected by an internal bus system which is isolated in consideration of the safety-technical requirements. In addition, this configuration opens up the possibilities for reciprocal monitoring of the three channels. This means that a possible defective behaviour in a measurement chain will be recognized and indicated by means of an error code. This error recognition system installed on the DESY-3 makes possible ear-

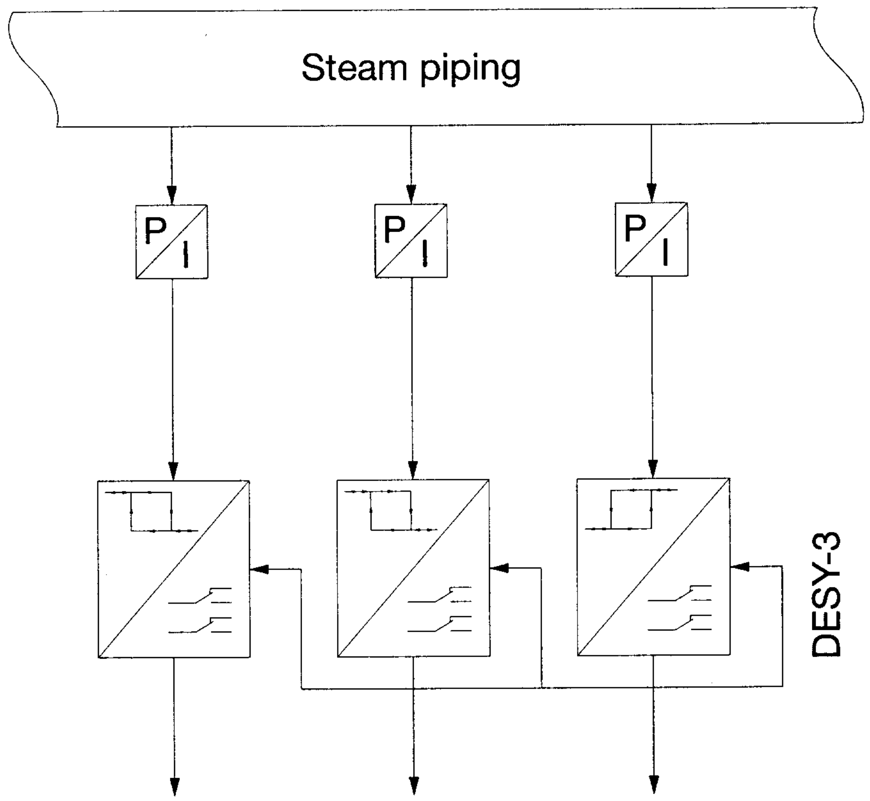


Figure 5. Pressure monitoring with the DESY-3.

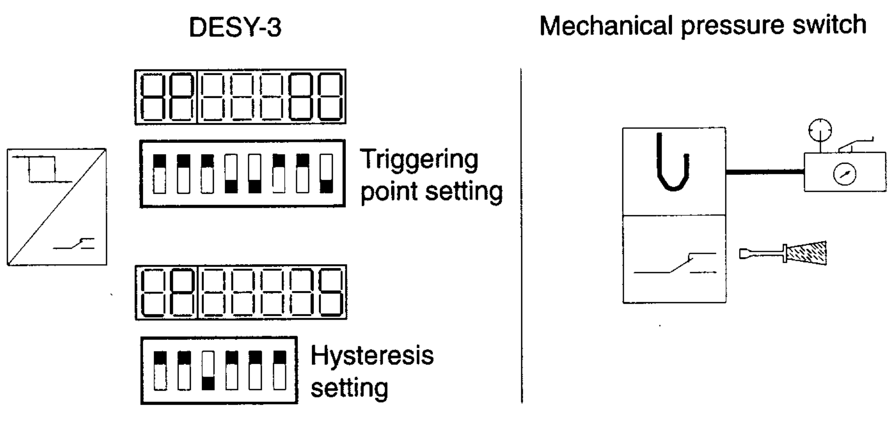


Figure 6. Adjustment of the DESY-3/mechanical pressure switches.

ly-warning indication of irregularities in the measurement system. The possibility of being able to react to errors being indicated in advance leads to a considerable increase in the availability and safety of the total system. Under certain circumstances, it is even possible to change a pressure sensor during operation of the installation.

The following defects trigger a signal but do not lead to shutdowns:

— failure of a pressure sensor,

— failure of an analogue-digital converter,

— impermissible deviation of the measurement signals of a pressure sensor,

— deviation of the configuration of a measurement channel,

— defect in communication between the channels via the internal bus system.

The following defects trigger a signal and lead to a triggering of a safety function:

— breakdown in the supply voltage,

— breakdown of measurement signal in more than one pressure sensor,

— exceeding the triggering pressure adjusted on a pressure sensor.

Defects occurring are signalled by means of an integrated alarm relay as well. For the purpose of protocolling all data, the DESY-3 is equipped with a serial EDP interface.

Insensitivity to Excitation of Oscillations

The measuring transducer has a considerably higher internal frequency in comparison with the excitation spectrum in a steam column, and is therefore insensitive to such excitation.

The electronic components are located outside of endangered areas owing to the physical separation of pressure sensors and the switch cabinet. As the amplitude peaks do no exceed the response pressure set in the case of excitation of oscillations from the steam column, it does not result in activation of the output relays and, as a consequence, triggering of the safety function does not occur.

Tests Made

— Immunity to defects resulting from electrical influences (EMC),

— atmospheric testing at -20 °C and 60 °C,

— insensitivity to excitation of oscillations,

— safety considerations based on inspection lists and test cases.

All of these tests have been successfully carried out. Virgin and recurrent tests were prescribed which are listed in Specification Sheet [5] on component testing from the VdTÜV (Technical Inspection Association).

Constant Triggering Point

Through the application of high-quality measuring transducers, a displacement of the triggering point caused by the aging of components under mechanical stress is eliminated. Temperature deviations are compensated for electronically. These properties guarantee long-term stability eliminating the need for complex readjustment operations.

Precise Adjustment

Experience shows that the adjustment of mechanical pressure switches is both complex and imprecise. The adjustment of such switches is carried out with the assistance of tools requiring operating personnel to have a high degree of skill. Adjustment operations are, therefore, generally carried out several times.

The adjustment of the DESY-3 is carried out digitally via so-called DIP switches (Figure 6). By means of these switches triggering and/or release points (hysteresis) can be exactly defined. Using indicators, the operators check their adjustments directly. In addition, DESY-3 independently monitors the concordance of the three channels. The comparison with a pressure-gauge tester in only necessary on annual checks by inspectors.

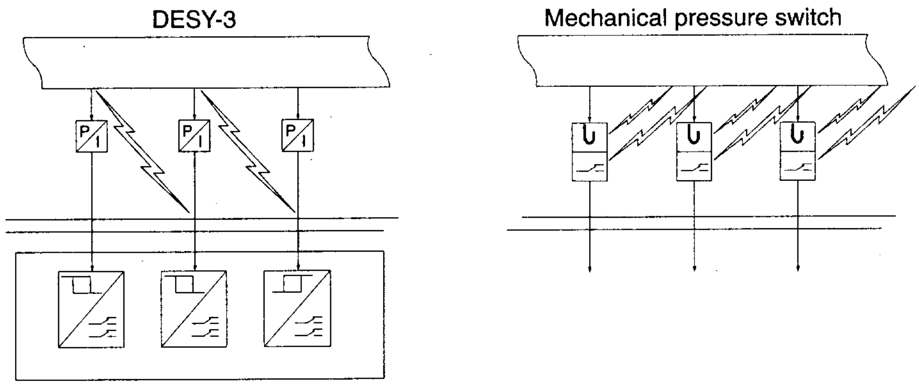


Figure 7. Effects of interference.

Economics

If one compares the costs of one unscheduled boiler shutdown which could have been avoided through the application of the DESY-3, the costs of equipping the installation with the DESY-3 would be only minor.

The stable operating characteristics of the DESY-3 make it possible for installation designers to have operating pressures come closer to permissible system pressures thereby increasing the installation efficiency. The replacement-parts requirement is limited to only a few components, as the DESY-3 can be utilized for all pressure ranges.

Retrofitting existing electro-hydraulic and electro-pneumatic control systems is also possible after clarification of installation-specific characteristics.

Summary

DESY-3m the 3-channel pressure recording system:

— replaces mechanical pressure switches in electro-hydraulic actuator systems for activation of protection valves and fittings in accordance with TRD 421,

— guarantees high operational safety and availability,

— minimizes triggering errors,

— monitors independently all measurement circuits using 3-channel construction,

— signals irregularities via an error recognition system,

— ensures simplest possible handling of adjustment operations and functionality testing by means of status indicators and signalling.

Bibliography

[1] Technische Regeln für Dampfkessel (TRD) 421; Sicherheitseinrichtung gegen Drucküberschreitung – Sicherheitsventile – für Dampfkessel der Gruppe I, III und IV; Proposal, September 1996.

[2] Arbeitsgemeinschaft Druckbehälter (AD) Specifications Sheet A2: Sicherheitseinrichtung gegen Drucküberschreitung - Sicherheitsventile; November 1993.

[3] Richtlinien für die Bauteilprüfung von Sicherheitsventilen für Dampfkessel und Druckbehälter; VdTÜV-Specifications Sheet Sicherheitsventile 100.

[4] Bräuer, J., Bung, W. and Kempkes,B.: Elektronische Drucküberwachung für gesteuerte Sicherheitsventile und Sicherheitsabsperrventile; VGB Kraftwerkstechnik 77 (1997) Pamphlet 3 p. 197-200.

[5] Bauteilgeprüfte Steuerung für Sicherheitsventile, VdTÜV-Specification Sheet Sicherheitsventile 710.