The Possibilities of Acoustic Emission Systems A-Line32D for Determination of Various Types of Defects

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An Acoustic Emission (AE) method of Non-destructive Testing (NDT) has widely adopted for diagnostics of various dangerous industrial objects for the latest years. The advantages of AE method are: detection and registration only of progressive defects, classification of defects by dangerous level, high sensitivity due to the growing defects, integrated ability to provide tests of whole object.
The A-Line32D complex allows to find and to evaluate of danger degree of AE sources, caused by the following defects: in main metal and welded junctions (cracks, stratification, backfins, loss of metal due to a corrosion and mechanical origin, faulty fusion, fistulas, burn-through, craters, gas pore, slag inclusions), outflow of gas and liquid in vessels and pipelines, presence of active corrosion on a surface of metal, presence of an electrical breakdown in reactors, transformers and insulators of high-voltage lines, and much more.
Now AE is used widely as main method of complex monitoring systems for dangerous objects.

INTERUNIS holds the leading positions in the field of non-destructive testing in Russia in acoustic-emission equipment production, inspection of industrial safety and creation of AE monitoring systems for significant objects.

Acoustic-emission equipment production

Since 1989 INTERUNIS is the developer and producer of equipment for non-destructive testing. Acoustic-emission systems A-Line 32D are well known.

A-Llne 32D (DDM) - represents the new age of A-Line32D digital AE systems family. Being multichannel modular system for data acquisition and processing it utilises high-speed digital data transfer channel. Latest advances in microelectronics and digital transferring were applied for developing this system on *radiochannel*.

A-Line 32D (DDM) allows to examine and control technical state of pipelines, oil and gas storage vessels, plants and systems of oil refineries, pumps' pipes, metalconstructions, tank-care, bridges, cast details of railway care and others during manufacturing processes. Besides it detects and diagnoses growing creeks, corrosion defects, leaks, high-tension areas, damages of ferroconcrete bearings.

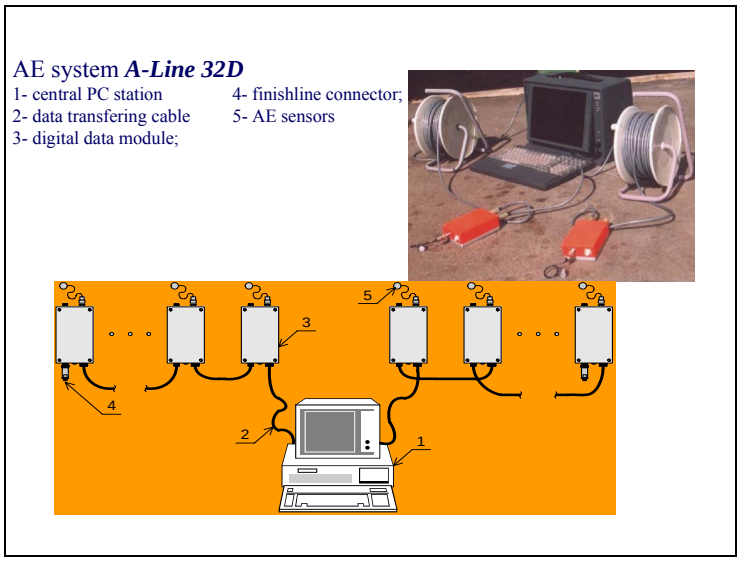

Fig.1 AE-system A-Line 32D, photo and block diagram.

Safety of A-Line 32D (DDM) is able to perform continuous real-time data acquisition and also can automate testing. All AE modules comes in explosionproof case. Every A-Line 32D (DDM) hardware part is a subject for postproduction tests. Extensive testing applied to assembled systems afterwards. Primary data processing and AE parameter calculation performed in modules located directly on tested object. Processed data transmitted to host PC in digital form. Electrical isolation between modules is assured. One can test object of total length up to 5 km at a time with a single portable A-Line 32D (DDM) system.

Due to new design architecture A-Line 32D (DDM) can be used both as a mobile system for single AE tests and as a stationary system for AE monitoring with object operating ability. A-Line 32D (DDM) cable segments between modules may have different length thus allowing customers to choose cable most suitable for tested objects. Cable length may be extended by using standard connectors. This allows to place AE system and personnel as far from controlled object as needed. A-Line 32D (DDM) processes data, displays graphs and remains operational at data rates at up to 15000 hits/s per channel and even more.

Each AE module provides: variable gain, switchable filters (by software), pulse mode, digital oscilloscope with independent threshold and variable waveform length and sampling rate, three parametric channels which may also be used as control outputs, temperature sensor, 2-color LED indicating module state.

A-Line 32D (DDM) software, common for all A-Line 32D systems family, runs under Windows. Standard Windows tools can be used for additional data processing. Multilanguage support.
easy to use and setup. Acquisition and analysis mode system characteristics can be adjusted for user's requirements. Multiple-window and multiple-page interface for textual and graphical data represent in on-line and off-line modes.

AE signal classification assigns a class number according amplitude, location-dynamic and integral criteria. Various location schemes: linear and planar, zone and 3-dimentional (3D), vessel and sphere, vessel bottom – are included. Location results can be applied on flat and 3-dimentional model of tested object. Control reliability can be increased by applying flexible criteria for automatic removal of false AE signals (such as electromagnetic noise, refraction of AE signals) in on-line and off-line modes.

Location results can be applied on flat and 3Dimentional model of tested object.

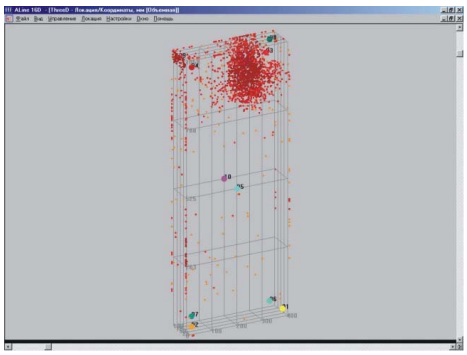

Fig.2 3-D location.

AE data filtration based on any single parameter or complex formula, on location and clusterization data, on noise and parametric data; graphical filtration, deletion synchronous interference.

A-Line32D Software includes extra possibilities:

- additional graphics, representing weld map or even the whole object, can be applied on any window in on-line and off-line mode for better location results representation.
- utilities for measuring AE signals' velocity and attenuation.
- AE testing report with corresponding graphical information is prepared and printed in user-selected type and colour.
- export all data to ASCII format for advanced processing.
- spectrum analysis of AE signals is a useful tool for precision AE waveform analysis. FFT (Fast Fourier Transformation) can be applied not only to full AE signal, but also to its parts. It makes our program suitable both for objects control and for laboratory researches of AE signals. Besides, we provide statistical analysis utilities for large sets of AE signals.
- correlation analysis of AE signals registered by different sensors, and their spectra allows to make conclusion about probable signal origin. Moreover, correlation is used for leakage detection in tested object.

Inspection of industrial safety

One if the activities of the INTERUNIS company is carrying out the expertise of the industrial safety of oil, gas, chemical, and oil processing objects.

All the work is performed by op quality specialists who were certified according to the international quality standards. Our personnel is trained on II and III levels of qualification of different control methods.

Also INTERUNIS carries out the research and develops existing technology in the field of acoustic emission.

Acoustic emission control is being made with the equipment produced by INTERUNIS, thus, allowing our personnel to change or improve its functional parameters efficiently and precisely.

During the technical diagnostics there is no need to stop the production process of the object, thus allowing our personnel do significantly decrease the amount of preparations.

AE control of *pressure vessels* can be performed during plan hydraulic tests and is obligatory at pneumatic tests due to increased security. And defects that can come out only during the normal work are revealed. The object keeps on working during the tests;

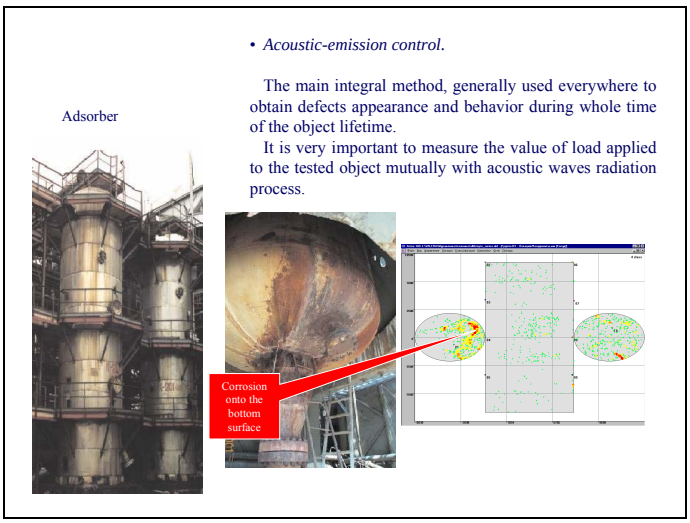

Fig.3 Determination of defect on adsorber.

Tanks and reservoirs are controlled instantly whole. The defects at the bottom and in welding near the base of the tank are revealed and their position is determined. The object keeps on working during the tests.

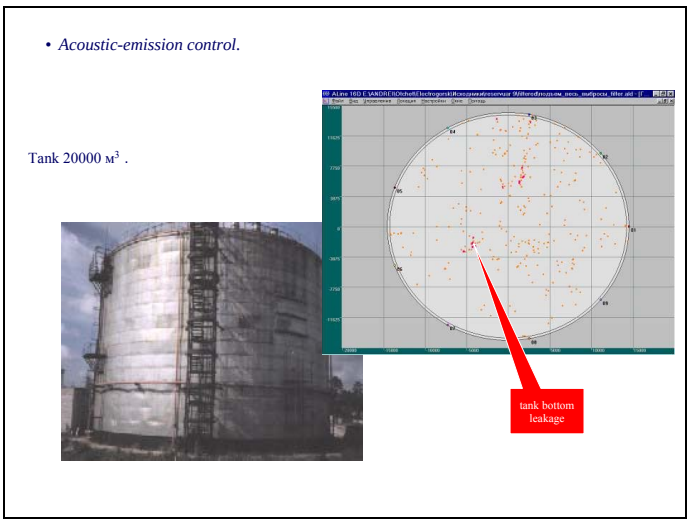

Fig.4 AE-testing of tank bottom.

Cracks, corrosion, splitting of a pipeline walls are determined in control of *Trunk and field gas and oil pipelines*. Sections up to 2800 meters are controlled. Object is not taken away from exploitation. Control can be done during repair. Pipeline control can be done in weak grounds and in caves.

Reliability of technical examination is increased under AE-test of *Pipelines of technological communications of compression stations, gas-processing and oil processing plants*; *Pipelines marches through natural and artificial hindrances.*

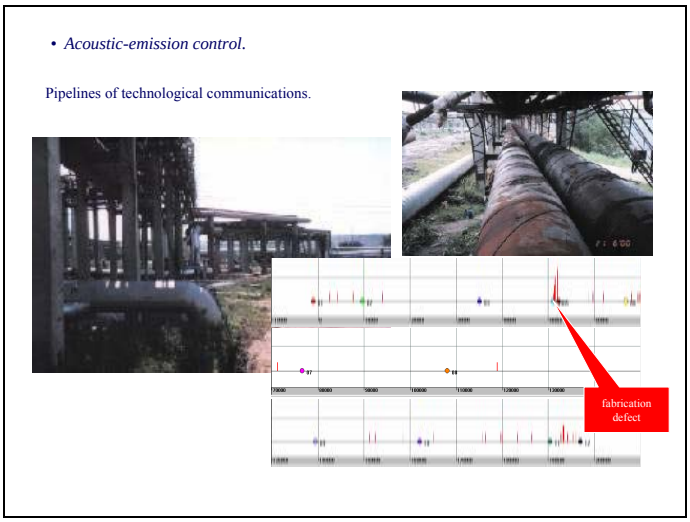

Fig.5 AE-testing of pipeline.

Bridge, portal cranes and another lifting apparatus during static and dynamic tests with AE-equipment.

Micro-cracks are detected in *wheel pairs*, *truck bolster*, *side frame*, *tank cars* of Railway transport objects.

In last years AE equipment is used on test of object of energy system, such as *porcelain insulators* of high voltage electric lines, *anchor bolts* of mast strengthening cable of high voltage electric lines, and breakdown detection in *reactors* and *transformers*.

And new AE testing field is *concrete*, for example *Bridge and viaduct piers*, buildings, hydroelectric power station.

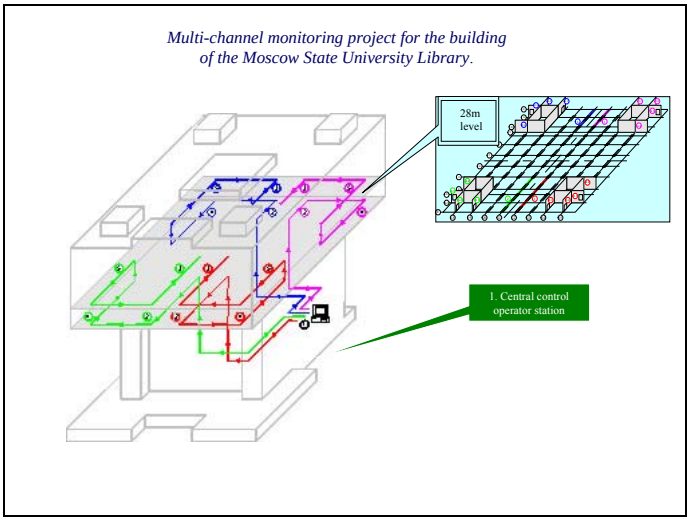

Fig.6 AE-monitoring system for building.

Complex Diagnostic monitoring Systems

The complex diagnostic monitoring of dangerous industrial objects, represents set of the technical measures allowing to carry out the continuous control of an actual technical condition on the basis of various non destructive methods and technical work parameters.

Objects, on which it is necessary to establish systems of complex diagnostic monitoring (SCDM) should have the following attributes:

1. The destruction of a design can result in significant material and ecological losses, human victims;

2. The access for realization of the periodic control of a design is absent or is complicated.

3. The periodic diagnosing is impossible or is connected to the large labour input of preparatory works and control;

4. The design has low operational survivability.

Absence of access for surveys of a design or the significant difficulties with access result in the large material inputs on realization of preparatory works carried out on object for realization of periodic surveys, creating a situation at which such surveys economically become inexpedient. Systems of diagnostic monitoring of designs in this case is without alternative by variant, and the expenses of time are determined only by time for installation of system of diagnostic monitoring on a design.

The labor input of the periodic control during operation of a design can be so great, that the expenses for realization of the periodic control become commensurable with expenses for overhaul or replacement of a design, and the large volumes of periodic surveys frequently result in decrease(reduction) of reliability of the control and occurrence of mistakes.

The speeds of development of defects (operational survivability of a design) can be such, that time between the moment of occurrence of the minimally found out sizes of defects and moment of achievement by defect of the critical sizes, at which there is a destruction of a design, less or is commensurable with an interval of time between the next surveys. This circumstance results to not to detection of defect and his(its) miss(passing) with all consequences, following from it.

For realization of potential opportunities of diagnostic monitoring it is necessary to have precise representation about a spectrum of operational loads, additional factors of formation, accelerating process, and development of defects, kinds of defects and methods of the control suitable for detection of these defects.

In SCDM process of data gathering, the identification of defects is carried out automatically in close communication with the current operational loads. This fact has determining meaning at detection of cracks, and as for the subsequent automatic identification such as defect.

Kinds of operational defects are corrosion, deterioration of walls, crack in welded seams and in the basic metal, change of a design rule (situation) of a design.

These defects are characterized by a number of parameters, which influence as a choice of a method of the control: site, orientation, sizes and speed of defect.

The site of defect can be known beforehand (from experience or from accounts) or the defect can settle down in any place of a design (for example, corrosion or crack from industrial defect). In the first case for detection of defects one of methods of the not destroying control in a mode of the local control can be used, when the gauge settles down directly in a place of occurrence of prospective defect, for example gauge for the ultrasonic control of thickness of a wall, in the second case the application of methods of the control of an integrated type is required, when all volume of a design is exposed to the control and the gauges can settle down

on the place, rather removed from defect. The method of acoustic emission concerns to such methods.
In system of diagnostic monitoring the growth rate of defect is not critical parameter, for the periodicity of interrogation of gauges in SCDM can be chosen anyone proceeding from the maximal speed of development of defect.

The block diagram of system SCDM is created on the basis of a concrete design of object of monitoring, spectrum of operational loads, kind of operational defects and methods, used for their detection, and means of the control.

AE-control represents the brightly expressed method of an integrated type of the control used in complex systems of diagnostic monitoring for detection of defects, developing while in service.

Ultrasonic test is used in system of diagnostic check for service of local sites of a design described by intensive deterioration and high probability of crack occurrence.

Strain measurement is one of ways of an experimental estimation loading-deformed condition of a design. Serves for continuous measurement of the current pressure in a design and comparisons them with design, provides automatic process of identification of a kind of defect on the AE data and other methods of the control used in system of diagnostic monitoring.

The displacement of elements of a designs caused by displacement of support, defects of the base under the tank or ground on a line of the pipeline are registered.

Vibrodiagnostic is used for measurement of dynamic loads in compressors and compressor stations pipelines.

System of corrosion monitoring is based on measurements of speed of corrosion metal of a design. The gauges on a principle of change resistance of an active element of silt gauges of an electrochemical type are used.

Fig.7 Sensors.

The creation of system of diagnostic monitoring is not limited to the analysis of design features and conditions of operation, spectrum of loads and defects by them produced, methods and means for their detection under operating conditions. The development of criteria for acceptance of the decisions about the further operation depending on numerical meanings of parameters is the key moment during creation SCDM.

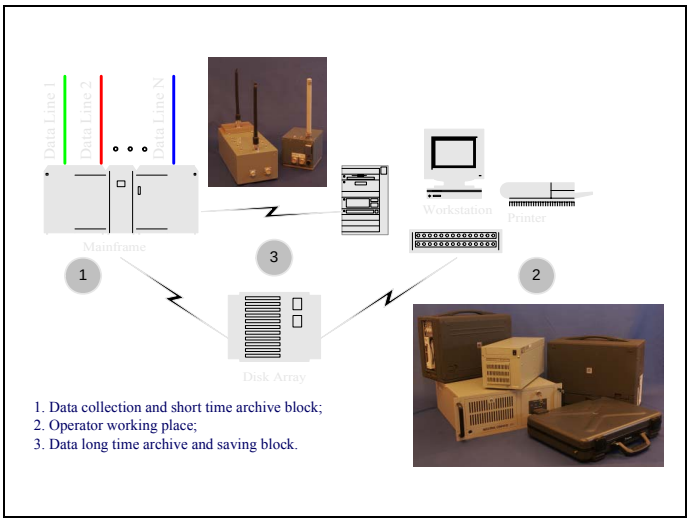

Fig.8 Stationary central operating-control station scheme

Essentially there can be two ways of formation of the decisions about the order of the further operation of object after reception of the information about presence of defect or malfunction of object.

The first way is characterized by that the flows of the information from primary converters, act while in service of object to the operator as the various messages on a board or monitor PC.

The operator on these data can accept the decision on continuation or suspension of operation, change of mode of operations of object or other decision ensuring safety of operation and safety of object.

The second way of acceptance of the decisions excludes any intervention of the operator in process of acceptance of the decisions, for it is carried out automatically by system SCDM on the basis of criteria.

The final result about the order of the further operation is formed as the concrete instructions or indications to the operator about influences on managing bodies of object to parry adverse influence of the found out defects or malfunctions on object or these influences are automatically developed by the executive mechanisms without participation of the operator.

Some approaches at creation of SCDM stated we shall illustrate on an example of bridges designs above.

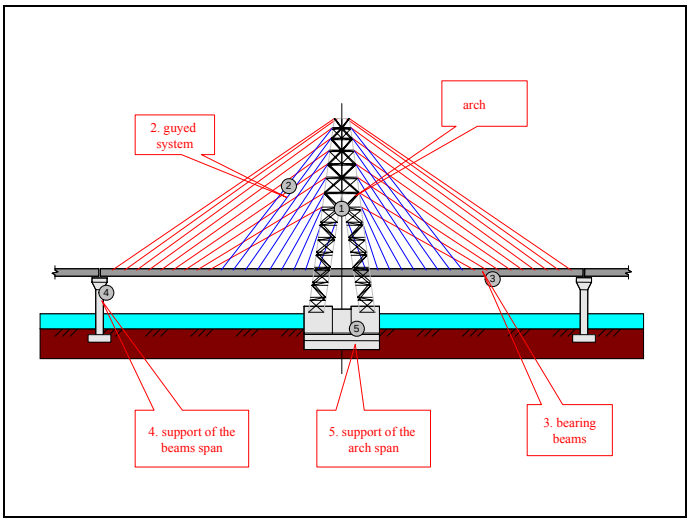

Fig.9 Monitoring project for guyed bridge construction (Moscow river).

The successful application AE method on bridge designs is promoted by a number of the factors, such as design of the bridge, kind of one-piece connections used in a design, kind of loads working on a design.

AE technology uses for detection of any defects in bonding connections of the arch pylon, guy bolting units, stringers and cross-beams, wields; guy bolting destruction events into the arch pylon; rupture of the high-strength wire, loss rope hardness; any defects in concrete supports of the beams and pylon spans.

Linear displacement and inclination sensors (including high-precision GPS) and also strain gages use for detection of any construction elements shifts increasing valid one and possible area where large deformations may occur, during various external natural or artificial factors.

Low frequency seismometers use for detection of any anomaly of the long period oscillation of the whole construction and possible influence of the ground moving effects onto the bridge construction.

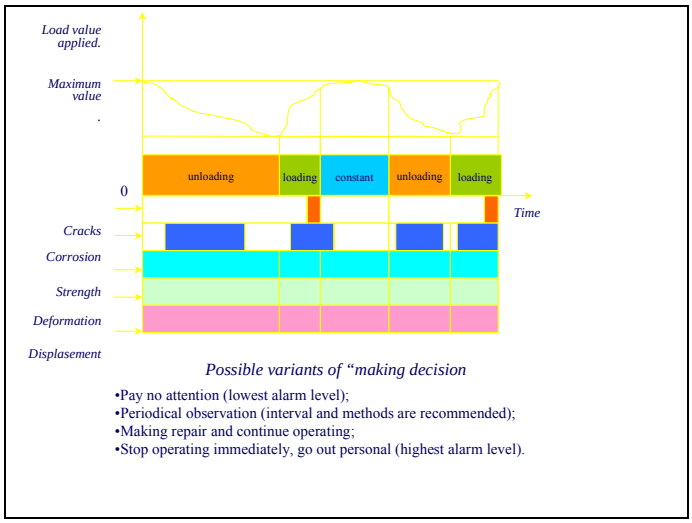

Fig.10 Defects classifying algorithm principle