USE OF AE METHOD ABILITIES FOR PETROCHEMICAL EQUIPMENT INSPECTION

B.S.Kabanov, V.P.Gomera, V.L.Sokolov, V.P.Fedorov, A.A.Okhotnikov
"Kirishinefteorgsintez", Kirishi Russia

ABSTRACT

This paper presents the results of AE inspection of the petrochemical equipment used at "Kirishinefteorgsintez". There were considered some special features of data analysis obtained during AE testing of the vessels. Some examples are given in order to illustrate the abilities of AE method for useful information collection about the metal structure of such equipment.

INTRODUCTION

One of the basic tendencies of modern refinery is the full recovery of all possible products from crude oil. Sometimes the solution of this problem is possible with using technologies more applicable for chemical industry. Due to this reason large refineries introduce new petrochemical processes for automotive gasoline and different fuels production. Moreover, such production is more profitable from commercial point of view, than traditional product manufacture.

Thus the appearance of the chemical technologies is oil refineries is the objective reality, but it means the introduction of a new processes, new chemicals usage and it demands the new experience and skills for safe equipment operation. It is very important when the new process is dangerous.

Kirishi refinery has the LAB-LABS plant, which produces the feed stock for synthetic detergents. This plant is the only one in Russia. Its production is used at all Russian enterprises manufacturing detergents and it goes for an Export too. The unit produces alkyl benzene and alkyl benzene sulfonic acid on the base of heavy cuts obtained during refining of crude oil. The main catalyst of the process is hydrofluoric acid (HF). This chemical is very dangerous product. The common process mass is about 170 ton.

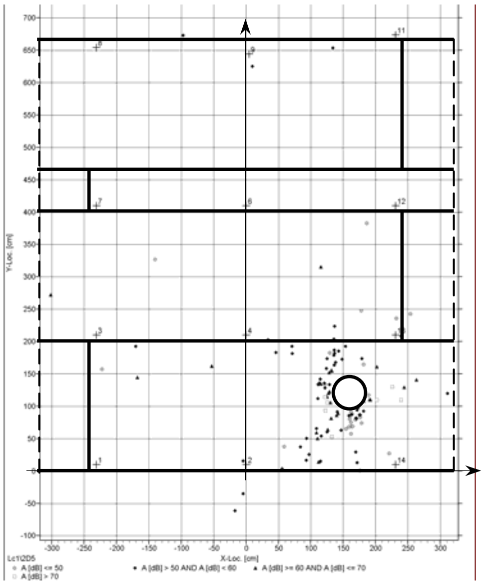
We know the AE inspection abilities for the refinery equipment well enough. Our experience has been based on more then 300 pressure vessels tested since 1992. However, in the case of LAB equipment we needed new AE inspection skills. Some results we obtained during AE testing of that equipment are presented in this paper. For AE testing we used two AE systems: AMSY-4 and LOCAN AT.

EXAMPLES

The design of the most vessels and apparatus (except of some unique) is the same as those are used at the refinery. The principle difference is the parameters of the make up media and how it affects the condition of the equipment.

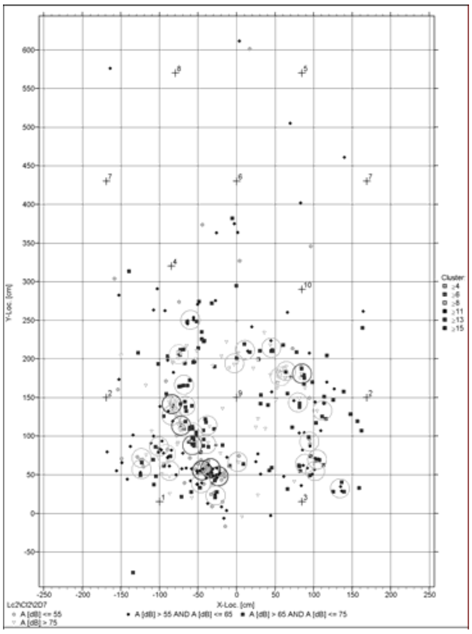
The first results looked familiar for us based on our experience of data analysis of our traditional objects. For example, Picture 1 presents the results of planar AE sources location at a small vessel reamer with the capacity of 23.5 m^3. The groups of AE sources, formed the location cluster, were registered at the shell parts, containing the internal discontinuities of metal. It was confirmed by ultrasonic inspection. At this stage of the test we did not pay much attention to the character of sources localization – they located around the weld of the manhole. The reason of such localization was determined later- in conjunction with the test results of the other vessels.

All the more, some objects of AE inspection exhibited the generation of AE activity, which character was not typical for our common practice. For example the hits energy at the AE testing of the heat exchanger shell had very high values, non-adequate to the expected ones. The additional inspection methods for the parts of the shell indicated by the planar location did not discover any real reasons for such high activity. Originally, the shell of heat exchanger reamer was considered as the plane of location (Picture 2). Because of the tube bundle had been inside of the shell during the testing, it was considered that it could be the source of activity. We made a note, that in accordance to our previous experience, AE sources, which were initialised by the development of different processes in the tube bundles (leakage, corrosion cracking of the tubes), had the energy level of the signals significantly less than in this particular case. We use, rather successfully, the algorithm of 3-D dimensional location for defects search in tube bunches.



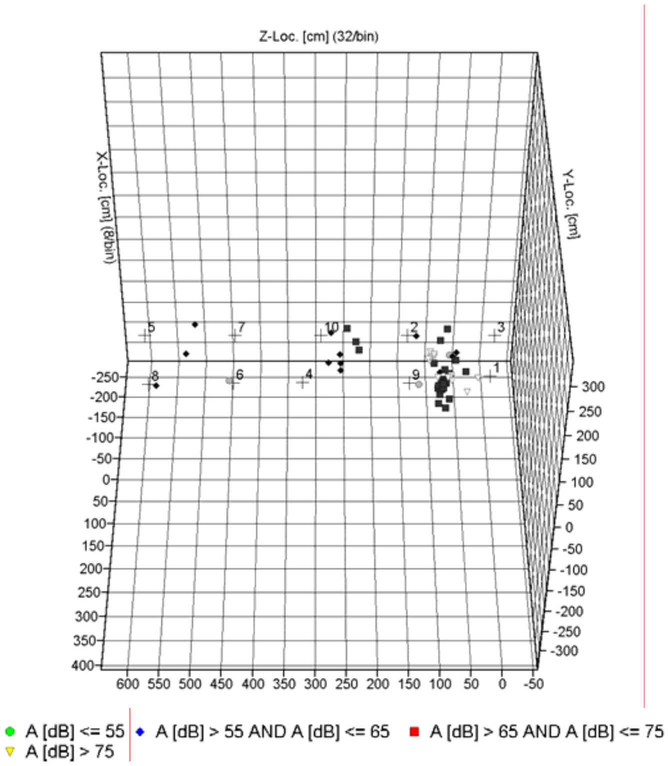
Picture 1. Vessel V=23.5 m^3 inspection results of planar location sources.

Due to application of such location diagram (Picture 3) it was localised the inner part of the apparatus in region of the distribution chamber. After the exchange had been opened it was found that during exploitation a lot of deposits and salts of HF acid were collected in that place due to the dead zone. Those substances according to their properties formed the hard solids looked like the concrete. The loads during AE testing causes the process of many cracks formation in this hard structure accompanied high AE activity. Because of this formation occupied the significant part in this cross of the apparatus decreased the efficiency of the technology process, they were removed mechanically.



Picture 2. The formal planar location results at the shell reamer of heat exchanger. It was not correct because main AE sources located inside space shell.

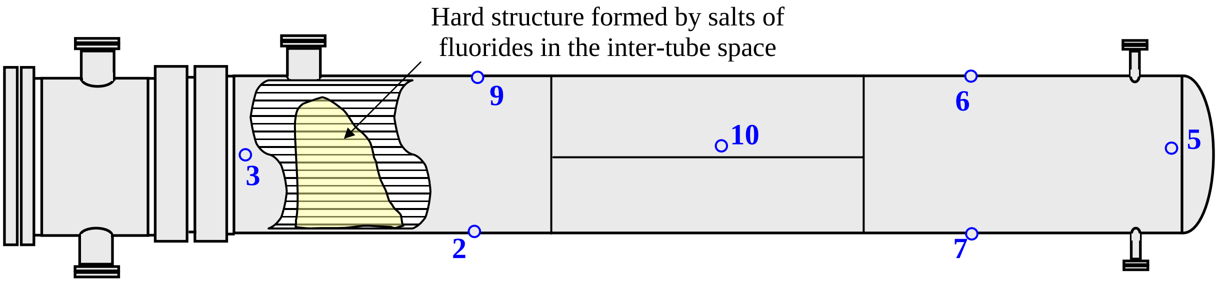
Evidently the case with the exchanger was rather exotic in the AE practice (though this result had the practical meaning for such type of the equipment and may be used in future). It serves as a specific warning for the possible surprises, may be found at AE inspections of LAB-LABS equipment.



Picture 3. Results of 3D-location for heart exchanger.

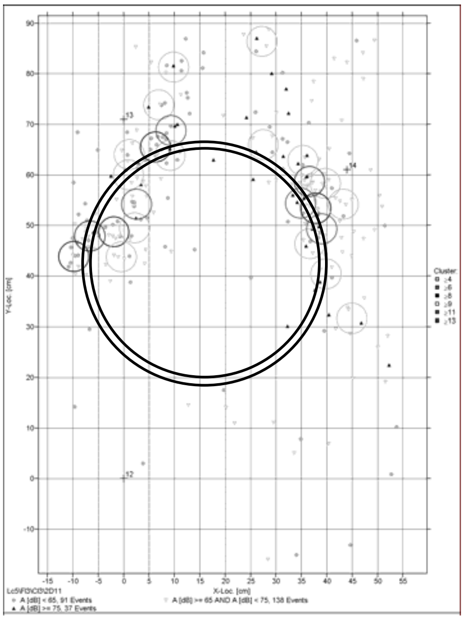
And we received unexpected for us results soon. It was received during the AE inspection of several vessels' group. The first of its was the reactor for mixing HF acid (the vertical apparatus with volume 80 m^3). In the Picture 5 there are shown the results of planar location of AE sources for the part of this shell near the upper manhole (nozzle diameter - 500 mm). During the additional check it was found the large zones of non-continuous of metal in the form of cavities near the welding (Picture 6). The same defects were found near the welding of bottom manhole. Those zones were repaired. The most probable reason of such defect formation was considered the metal splitting under corrosion factors in the places of the bad welding due to the metal stress.

Therefore the results of AE inspection of the next vessel with the volume of 243 m^3 where liquid chemicals are separated with sedimentation allowed doubting in that. Picture 7 presents the results of planar location of that vessel. Again there is high AE activity of the object. Moreover, the

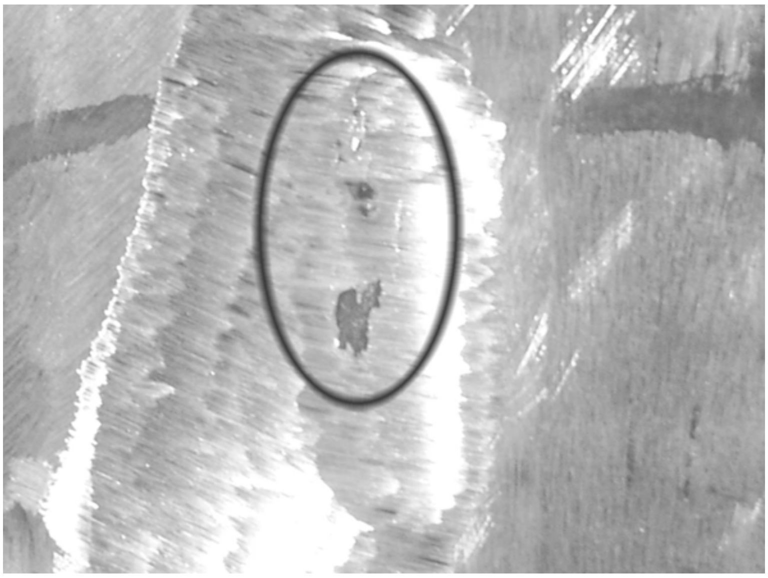


Picture 4. Scheme of heat exchanger contented unexpected object of AE activity.

high concentration of sources AE is visible at the separate parts of the shell reamer. The last fact is in good correlation with the levels of separated chemicals inside of the apparatus (Picture 8). The different degree of chemical corrosion (in condition that all metal surfaces is homogeneous) could explain such distribution of AE sources. But it is necessary also to consider the steel quality of which the vessel is made. It is possible the steel is not protective to some of the chemicals used in this process. We have met the same distribution of AE sources before, and as a rule it was connected with the large number of structure metal irregularities, they are small in size, but distributed on the large surfaces of the shell.



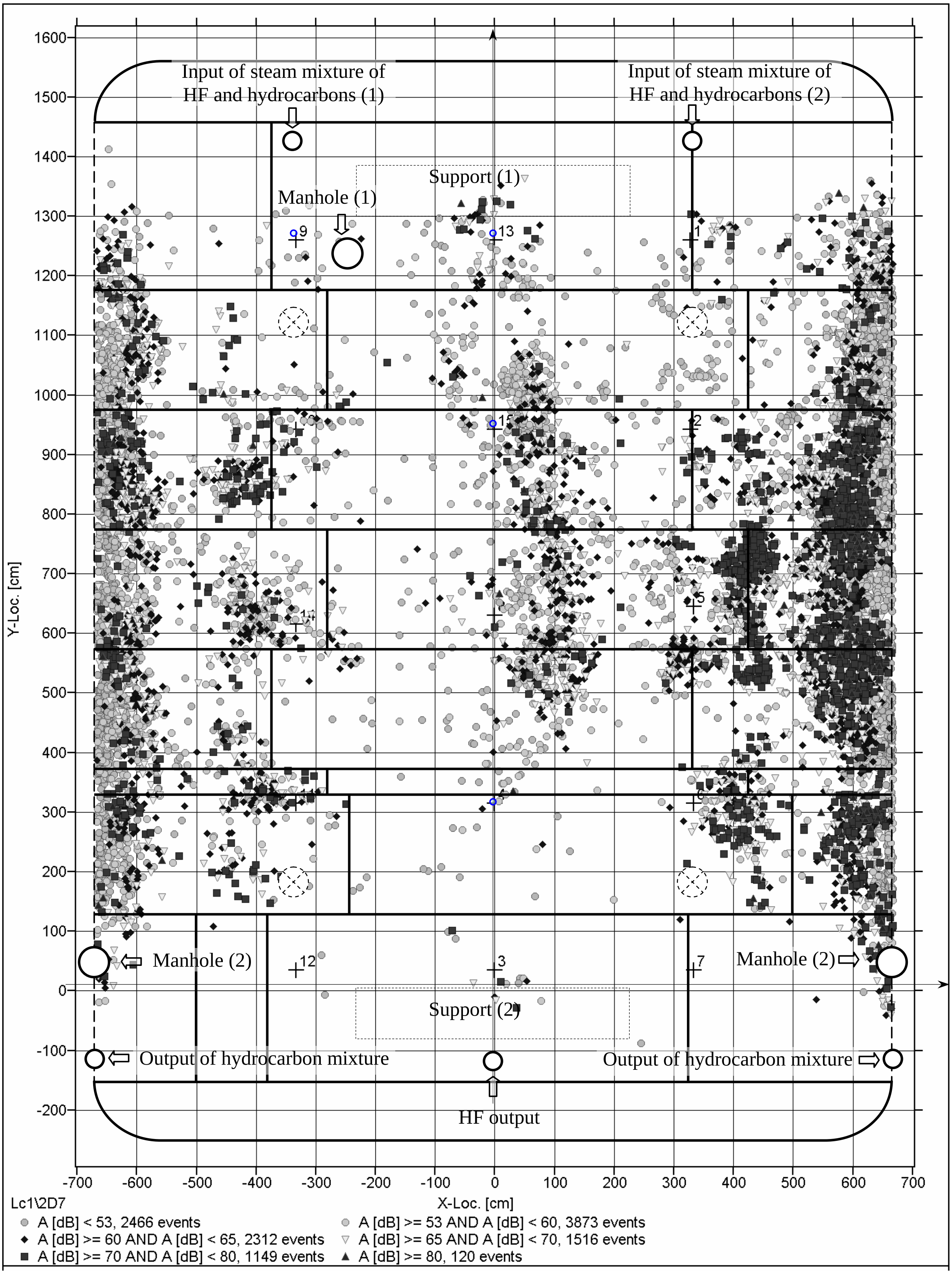
Picture 5. Results of planar location for the part of the reactor's shell near the manhole.



Picture 6. This is the picture of metal defect at the weld of the manhole of the reactor. It is shown the inner cavity in metal.

The base example is steel containing more non-metal inclusions (such as slag, oxides and sulphides) which are the collectors of atomic hydrogen, then it is prescribed in the specification.

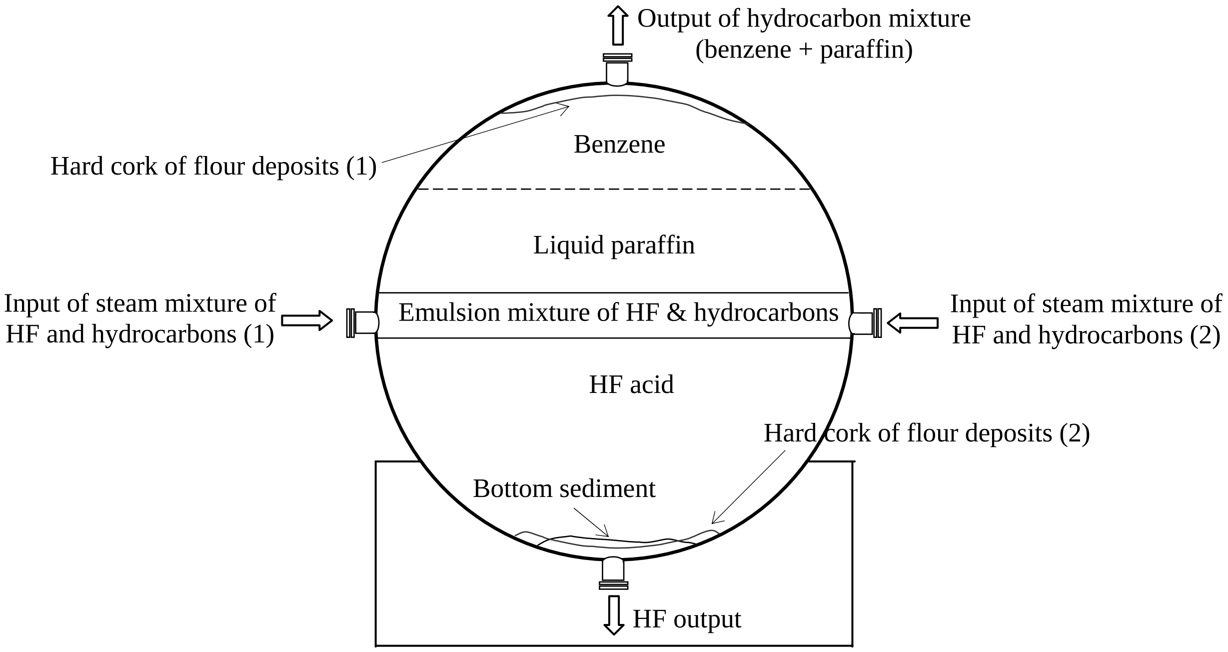
The equipment for LAB-LABS plant had been made in several European countries according to ASME standards. Then the authorized Russian organisation checked the correspondence of manufacture to Russian standards. For the reactor and some vessels manufacturing in Romania it was used the steel A516 Grade 70. The expert organisation called the Russian analogue of steel 09G2C (the abbreviation according to Russian standards). Steel 09G2C is included into the list of the recommended materials for such equipment manufacturing. One of the characteristic features of this steel is the presence of sulphide inclusions when there are the disturbances during its melting. That's why it was decided to do the metallography analysis of metal samples of the reactor.



Picture 7. Vessel (separator) V= 243 m^3 AE inspection results of planar location sources.

The analysis results showed the quality of steel had been good and the number of non-metal inclusions had been insignificant. Therefore the spectral analysis showed the vessels had been manufactured not from steel 09G2C as it had been indicated in their passports, but from steel of grad 20G. The structure of the metal was examined with the chemical method: ferrit + perlit; the corn point N8 (fine grained); structure had the banding formation (Picture 10).

This structure, as a rule, leads to non-continuous formations along the structural bands during exploitation under corresponding stresses. Because according to the Russian standards this steel is not used for the large part of equipment manufacturing. It's recommended fields of application are a manufacturing of bushes, tubes and unions. After thermal treatment it may be parts, which has the hard surface, but does not need the inner resistance (bolts and nuts, gears and other parts). And it must be small in size.



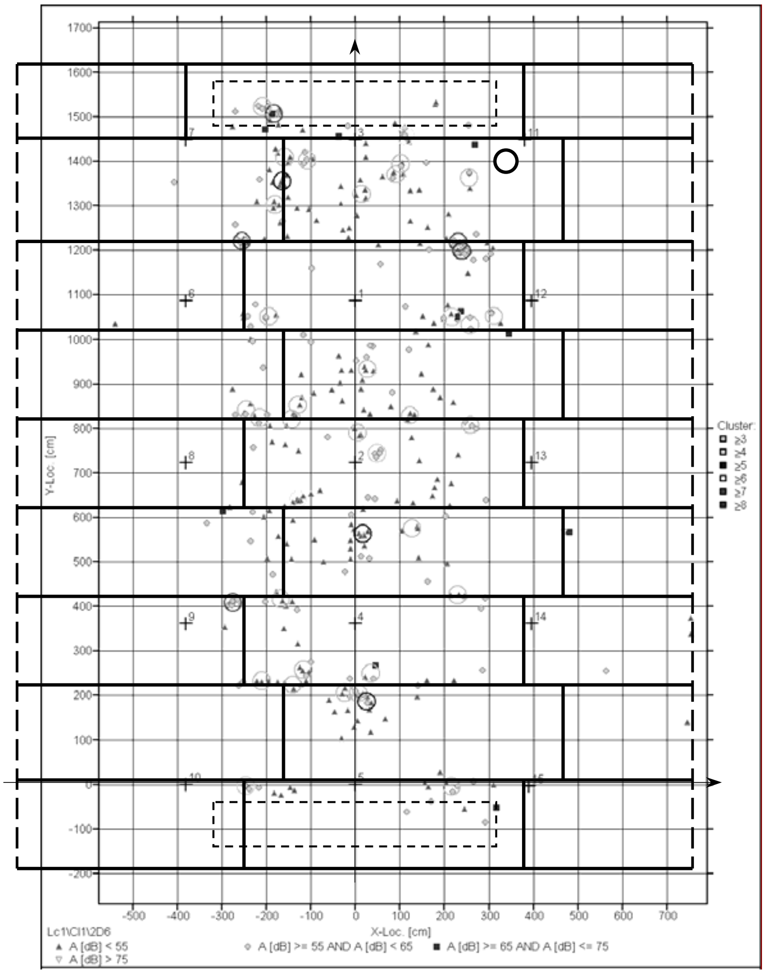
Picture 8. Base chemicals location in separator V=243 m^3. There may be observed the correlation with distribution of AE source activity.

According to ASME the steel A516 Grade 70 is used for vessels manufacturing which operate at the moderate and low temperatures. Due to this reason may be it's showed in some Russian-English steel's translators for the field of application such Russian analogue steel 09G2C. But the more exact of it's analogue is the steel 20G. Russian standard for the field of application of this steel is more restrictive. Taking into account our practice it is reasonable.

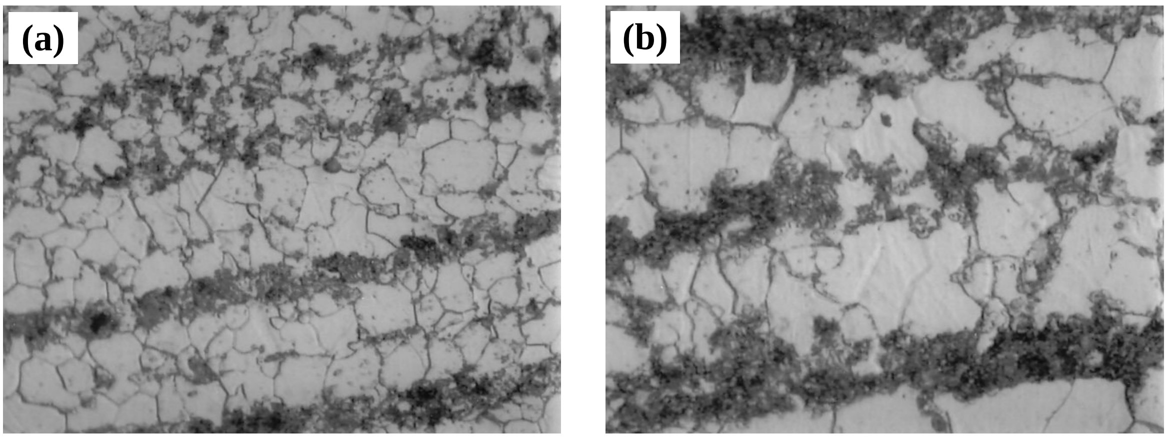
Let's come back to planar location results in Picture 7. This graph is the illustration of the properties of large size constructions, made of steel 20G. The graph shows the quality location picture (due to unavoidable -even due to static laws-speed dispersion spread through the metal). But this picture truthfully reflects the basic tendencies in the development of degradation processes of the metal:

1. Clearly expressed zone distribution in sources groups.
2. This distribution is possible to be analysed on the base of technology factors effect estimation (operation media characteristics) on metal.
3. Zones of concentration of AE sources are in correlation with zones of metal stress-in zones of long welding (it is the illustration of the fact of significant influence of scale effect on construction properties of equipment made of steel 20G).

The same tendencies may be seen in the example of vessel’s AE testing results with the volume of 360 m^3. It is used for chemical's storage and does not take part in the process. It operates in less corrosive conditions than the dram separator. It reflects in the intensity of structure changes development in the metal. But the zones of stress concentrations are exposed for this tank with the same evidence as in the dram separator (Picture 9).



Picture 9. Vessel V= 360 m^3 AE inspection results of planar location sources.



Picture 10. Metallography study results of reactor material (from different parts of the shell, outside of defect zones): (a) - specimen №1 (x500), (b) - specimen №2 (x1000). Banding structure for both specimens is presented.

It is necessary to notify this situation is not critical because now we have the needed information. Steel, in common, was 8 years in operation, but we found out the apparatus with hard operating conditions had some zones of accelerated degradation of it's properties and it corresponded the common characteristic of steel given in literature. According to the results of AE testing the reactor was changed for a new one. For the other apparatus it was determined the zones location where metal structure changes with high speed due to the exploitation factors. The quality estimation of relative intensity of different chemical's influence on metal was made.

This information was received, mainly, thanks to the usage of AE inspection and is one of the illustrations of AE method opportunity in real metal state studying of industry objects.

The technical stuff of LAB-LABS plant was persuaded in the AE monitoring system installation on the apparatus which work in hard operation conditions- HF mixing reactor and the vessel of the products separation due to the AE test results.

CONCLUSION

1. The traditional AE testing methodology kept its actuality for the new types of the equipment. It allows obtaining the acceptable results for practical applications.

2. Data of petrochemical equipment with AE testing reflects the known effects, but such effects may be displayed in the another scales.

3. Traditional methods and apparatus of AE method work successively, but there are met art facts, which demand the identification (for example fluorine deposits)

4. As the example with steel, which does not meet the specification, AE method may be used as the very exact research instrument even in the field of industry objects control.

From our point of view, the analysis of the events history which led to the one of more interesting result-type of steel determination shall be estimated separately. Non-adequate data of AE testing causes the metallography and chemical study and additional study of technical documentation. Our first consideration: the bad quality of the "right" steel was mistaken. But the power of the "message", which included in the data of AE testing was enough to lead us to the right results. May be the wrong intermediate results accompanied at the intuitive level of the harmony disturbance feeling, which means "normal construction - normal AE". Such feeling did not allow finishing the study at the intermediate stage.

It is connected, may be, that the obtained AE data has all the necessary information about the object condition, but we have no the right instruments of its optimal interpretation for the present.