BULETINUL Universităţii Petrol – Gaze din Ploieşti	Vol. LXII No. 2/2010	251 – 260	Seria Tehnică

Some Problems Regarding Technological/ Technical Monitoring, Diagnosis, Reliability and Security of Oilducts

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Abstract

The article presents some aspects regarding in situ monitoring actions and technical diagnosis needed for surveillance of oilduct processing parameters, detecting/diagnosing of the faults and rapid intervention in case of damages by applying maintenance operations, in order to maintain a high level of reliability and operation in conditions of oilducts technical security.

A series of modern monitoring, diagnosis and maintenance methods, procedures and tools are proposed and specified, and also new assessment procedures regarding oilducts capacity to be used in conditions of technical security and the advantages of their using.

Finally, the future objectives and directions necessary for a modern approach of the oilduct type systems are presented.

Keywords: *oilduct, monitoring, diagnosis, maintenance, reliability, security.*

Regarding the Oilducts Diagnosis and In Situ Monitoring

The existent faults (mechanical-physical, chemical, metallographic faults etc.), can be detected and technically diagnosed by in situ monitoring of all the specific intrinsic operational parameters of the oilducts, or you may rapidly and efficiently intervene to remove the faults if they are present. The detected faults could be produced by local distortion of the pipes, they could be of “lack of material” type or they could be detected as fissures or/and cracks.

Any of the technical (as regard designing, manufacturing and processing), organizational or professional competence circumstances of the involved personnel could be considered as causes of the oilducts faults. The dangers that might start the oilducts damaging could depend on the duration (external, internal and stress corrosion cracking), could be stable (manufacturing defects, fabrication-assembling/welding faults and equipments defects) and they could be independent of duration (mechanical damage produced by a third party, incorrect operational procedures and outside forces or weather-related).

In connection with these causes, the factors that establish the residual mechanical resistance and the safety processing of the oilducts having the pipes made by steel tubes, are: aggressiveness of the transported fluid/environment aggressiveness in which the oilducts are located, the steel quality of the tubes are made of, the construction conception of the oilducts and the operating conditions.

The real technical materials used for the oilducts construction are not perfect, that means they are with defects, according to some scientifically established criteria provided by norms and standards; therefore the defects could be admitted, temporarily admitted or not admitted and accordingly, assessments could be made regarding the service duration depending on the velocity the stable propagation processes develop with, in operation, and assessments of the defects and of the critical dimension of the defects when the unstable yield is initiated (breaking).

Technical diagnosis [1], that means isolation, identification as nature and proper quantification as shapes, types and dimensions of the defects is made by non-destructives technical diagnostic procedures (visual; based on sounds, vibrations and noises; by acoustic emission; in (electro)magnetic field; by special methods etc.). Non-destructive examination made during the manufacturing execution process, at the end of some established periods of time for technological examination-testing-verifying-functioning and/or in other circumstances (including alerts, damages or post-damages), has objectives referring to assessment or prediction of the value level of some material features (dependent on the metallographic structure or global) on the one side, and on the other side the objectives may refer to the fault assessment (based on the quality control functions and on the utilization capacity), including detection, quantification and processing of the fault condition. In the present, there is a tendency to correlate the criteria of the quality control (non-destructive) with the importance and the service parameters of the examined oilduct material.

The performances of every detection and diagnosis system are given by promptness, sensitivity, robustness, precision, economy, reliability, security etc., and the diagnosis and detection methods for the faults do not have a universal feature but they are specific for the respective system (oilduct), the most efficient and economical technical solution being chosen.

In the majority of cases, the oilducts breaks down appear as a result of damages and destructions by fissuring-breaking (due to creep, corrosion etc.) and not as a result of the mechanical usage, the diagnostic of the respective breaks downs being made not on the basis of the chemical analysis of the usage but examining the physical effects of faults (fissures) producing, extension and propagation.

The main natural cause of oilducts damages by fissures-breakings [2] is the great variety of external or internal corrosion (general, stress corrosion cracking, intercristaline, pitting, erosive etc.), which, opposed to the other types of faults are progressive, the metal loses being produced with high or low velocities, depending on the real processing conditions and the quality of the anti-corrosive protection. As a suggestive example, the figure 1 presents the number of damages produced between 2000-2008 at the ∅ 20 oilduct, having 324 km lengths, Constanța Sud 2 - ARPECHIM S.A. Piteşti, belonging to S.C. CONPET S.A. Ploieşti, where a number of 172 da-

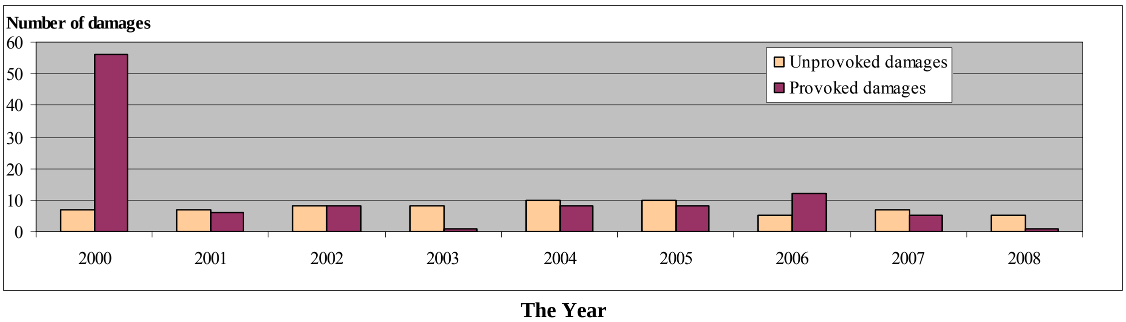

Fig. 1. Damages situation during the years, for 20" pipeline.

mages were registered, from which 67 damages were unprovoked (due to the corrosion), the rest of 105 damages being provoked damages, non-natural (human unauthorized interventions in order to stole the petroleum products).

The knowledge of the faults increasing velocity, lack of material type, produced by corrosion, represents a basic element for the oilducts processing management, the methods by which this velocity could be established depending on the available information, being:

- methods based on using some empirical, predictive models (experience from processing), or semi-empirical (using some laboratory tests, some databases containing corrosion velocities etc.);
- methods based on “in-line” inspections results, using PIGs based on magnetic induction principle, ultrasounds, eddy currents or of complex type;
- method based on external scanning robot (Robotic Pipeline Scanner);
- NO PIG method.

None of the examined methods and techniques does satisfy all the requirements regarding simplicity of use, the amount of the costs, the independence of the control technology by the faults dimensions etc. The most promising techniques, that are going to be improved and applied in the future on the industrial scale, are based on using of ultrasounds: Ultrasonic Time of Flight Diffraction – TOFD and Ultrasonic Phased Array – UPA (that imply a three-dimensional examination of the faults produced by stress corrosion cracking).

A relatively new method (applied in Great Britain and U.S.A.) for detecting the faults for progressive fissures type to oilducts is the pressometric attempt (hydraulic) to flow (high pressure) to the lower yield stress level material on the pipe. As a result of the development of the local plastical deformations, the possible faults are extended and leaks may occur, that could be located and quantified.

From all the known methods, procedures and means used for technical diagnosis of the oilducts, the most valuable and perspective is still the acoustic emission method (EA), used mainly and for the moment, for:

- detection of progressive faults in the wall of the pipe (Sulzer –Switzerland and Kockums – Finland);
- detection and location of the “leaks”(Accoustic Emission Leak Locaters – U.S.A. and AE International –U.S.A.).

In the technological-industrial practice for oilducts processing in U.S.A, Germany, Great Britain and France, the so-called “noise corelators” are also used (Metravib-France), remarkable opponents for EA, which offer the possibility to detect and locate the “leaks” until 600 m distance, no matter what the depth of the oilduct is.

Nowadays there is a tendency to create new technical tools to diagnose the linear segments of the oilducts. Due to the fact that there are many types of faults/discontinuities, it is necessary to use together, on the one hand, more methods, procedures and technical diagnosis tools and, on the other hand, it is necessary to improve them.

Every action of technical diagnosis aiming to establish the breaking causes in technological processing circumstances is always an independent expertise with many examinations, analysis, investigations and researches or autonomous studies. Therefore, the competence in this field requires appropriate professional experience, permanent data stocking in computer files resulting in so-called informatics banks, easy processing of the results (statistics, probabilities, predictions).

Regarding the Oilducts Maintenance

The main problem of the in situ industrial processing is the assurance that the oilduct runs without interruptions to the maximum capacity, so that the planned transported volume could be realized. For this, the services with attributions in oilducts processing and maintenance have to know all the designing and performing details for the oilducts [3] they process (included in the Technical Manual), in order to estimate the possible solutions that may allow changes in the technological conditions of the pumping (without risks).

In order to elaborate the maintenance programs that could assure a period of longer processing of the oloeducts, it is necessary to know their technical conditions. The precise and detailed knowledge of the oilducts permits adopting of the preventive and predictive maintenance systems which significantly decrease the risks of damages, by non-expensive interventions, in comparison with the corrective maintenance system.

In this context, the periodical inspections of the oilducts and the permanent monitoring of their technical condition are the cheapest and the most efficient methods to maintain the oilducts integrity, to assure a long life running and rational schedule of the maintenance works.

When the oilduct maintenance strategy is established, the following aspects are considered: the limit situations that could occur, probabilities of reaching the limit situations, the fluid volume that could be released in case of an event and the population density in the event area. As an example, in figure 2 is presented the distribution for quantities of crude oil lost by leaks, because of the unprovoked/provoked damages, until their repairing, during the period between 2000-2008, along the all ∅ 20 in oilduct length, having 324 km, Constanța Sud 2 - ARPECHIM S.A. Pitesti, belonging to S.C. CONPET S.A. Ploieşti. The 67 unprovoked damages resulted in leaking and losing of 193,699 tones of crude oil, and the 105 induced damages produced by 165 perforations of the pipe, resulted in leaking and losing of 21 729,157 tones of crude oil.

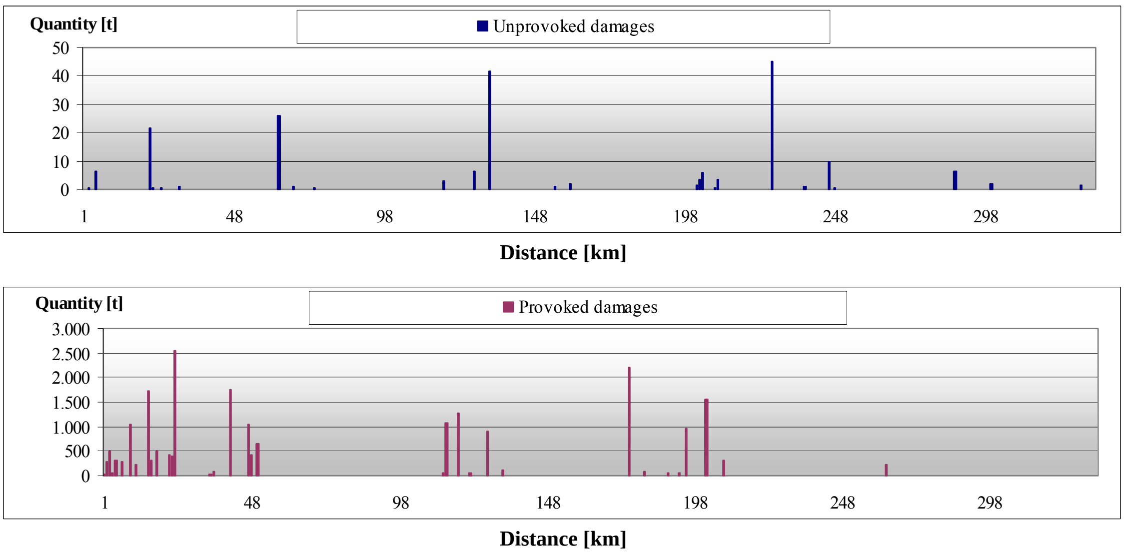

Fig. 2. Leakage of crude oil, due to damages, on the 20"pipeline length.

As a general principle, each maintenance work, rehabilitation and/or modernization program has to take into account the economical condition of the oilduct Owner/User, the emergency of performing the maintenance works as well as the technical specifications regarding accomplishment of the established works.

In the same time, when a maintenance program is set up for an oilduct, should take into account the reduction of the oilduct operation pressure and establishing of the appropriate moment to run the maintenance works. The decisions of reducing the operation pressure of the oilduct to a certain value and the moment of deciding to do the maintenance works implies some inherent subjectivism that may be counteracted by following some procedures established in the company or national level, based on technical specifications, norms, standards and regulations in force at that moment at the international level. It is necessary that these procedures to take into consideration the particularities of every transport system together with all the internal, external and environmental factors, that could influence the respective oilduct. Therefore, drawing up some general procedures, with possibility to change them depending on the real processing and environmental conditions of the analyzed oilduct, represents a future direction in respect of maintenance activities standardization, resulting in the increasing of processing safety.

In the present, the most used maintenance system for oilducts is the planned maintenance system. This system implies:

- a judicious planning and rigorous periodical technical revisions;
- a correct evaluation of the oilducts technical condition depending on the information gathered during the technical revisions;
- an appropriate schedule of the preventive and corrective maintenance works.

The imprecision of the oilducts technical condition assessments could lead to incorrect planning of the maintenance works resulting in coming out of some unpredictable cessation phenomena as accidents or damages. For this reason, it is necessary to use the planned preventive maintenance system in parallel with the unplanned corrective maintenance system. As a conclusion, the maintenance systems used for the oilducts have to be structured as such manner to foreseen applying of some vast corrective maintenance works, with all the implications regarding technical, organizational and economical aspects, at reasonable time periods, such as rehabilitation and/or modernization works for some oilducts segments. In this context, the decision to include some preventive or corrective maintenance works has to be taken based on some correct evaluation with regard to the oilducts capacity to be used in technical security conditions, taking into account their life duration.

Now there is a tendency that this evaluation (defined as the Fitness For Service-FFS concept), to be made based on a procedure –scientifically proved and regulated by scientific works, standards or norms [4]. The evaluation procedure of capacity to use Fitness For Service in the case of oilducts comprises technical specifications regarding estimation for their residual mechanical resistance in the presence of some different types of local faults and/or in the presence of some degradation phenomena and mechanisms. For the faults with unique mechanism of producing, the procedure could contain multiple interpretation methods or procedures. The appropriate repairing methods are stipulated in every Fitness For Service evaluation procedure, each situation requiring a careful choosing of the intervention type. After the intervention, periodical controls have to be made in order to establish if the maintenance activities prevented some other damages and the conditions could assure the future protection against new faults.

Informatics is necessary in order to set up the basis of a modern and efficient industrial maintenance, that allowing capturing the huge volume of data and information specific for maintenance and using of modern techniques and methods in drawing up the strategies and taking decisions. Informatics in the maintenance management field is a competitive “tool” for the maintenance management, able to assure choosing of that maintenance strategy appropriate for the specific conditions in each company. This informatics allows administration and knowledge of all the technical and economical information needed to perform the maintenance in optimal conditions. Such a system performs the "total" administration of the equipments by setting up a unique and complete data base for equipments and maintenance works that take advantage of the last experience and all the technical and economical information it has.

The experience shows that even from the first year of using such a system you may have maintenance costs reduced to 15%, and finally to 25-30%. The companies with such a system have a decrease of corrective maintenance in the favour of planned-preventive maintenance. If the company have devices for in situ monitoring of the specific features equipments (pressure, temperature, vibrations etc.), the system could use these information to prevent the faults. The system establishes with high accuracy the moment when the equipment must to be stopped for an intervention, so that it may obtain a cost saving by optimizing the moment of introducing the equipments in the maintenance process.

The technological methods for rehabilitations in maintenance procedures applied to oilducts (straightness/grinding, applying of welded parts etc.) are made using the welding as main method. It appeared new technologies (covering the internal surface of the oilducts pipes with resin, U-liner procedure, Phoenix procedure), which fix the internal corrosion problems without welding. Of course, every time when there is a maintenance operation for an oilduct, the personnel must check and repair the external isolation.

The technological solution chosen to perform every maintenance work for an oilduct must be verified (experimental, on the oilduct elements at real scale, on models, by numerical simulation etc.), in order to see its effects on the mechanical resistance of the oilduct and in order to assume the permanent or transient character of the maintenance work. The main objectives of the checking are:

- to establish the main structure changes and mechanical properties modifications produced in the termically influenced area of welded joints, realized between the pipe and the supplementary element used (part, collar, cover etc.);
- to establish the field of residual mechanical tensions generated by welding operations in the pipe and in the supplementary elements used;
- the analyze of mechanical work between the pipe and the supplementary elements used;
- the analyze of correct dimensioning for the suplimentary elements used.

Regarding the Oilducts Security and Reliability

Reliability is the probability – for a certain element, a structure or a technical system (oilduct) – of not going out of work, that means not to cease by being out of order, in a given period of time, in established technological and environmental work conditions; the complement of reliability is non-reliability.

From the point of view of quantity, the probability that an event generating a major damage, or that the real major damages to be produced represents the technical risk and the probability that a major damage to occur represent the technical security.

The industrial practice proved that it is not possible to assure an ideal reliability, no matter of how many investments are made in order to maintain a high level of reliability for a technical system (oilduct) that means there is no oilduct without degradation in time. In the same time, an insignificant increase of the reliability level in its high values field usually means a substantial increasing of the investments costs involved into conception and setting up phases of the respective oilduct. In these circumstances, it is mandatory to assure and maintain optimal level of systems reliability; their evaluation is generally made according to some managerial criteria, the involved variables being destination and importance of the system, the planned processing period, the investment (conception and setting up) and processing costs.

Security of systems operation represents, through its four specific components (security, availability, reliability and maintenance), a basic component of the processing requirements. The common point between the security components of the systems is represented by using of the probabilistic tools as a technique of risks assumption for different operation stages of the analyzed system.

Assuring of some high level of reliability and technical security for an oilduct is conditioned by fulfillment of the following mechanical and technical security criteria:

- assuring of the mechanical resistance for the structural components; this means to avoid reaching the critical limit situations in using the material into operation (potentially dangerous or ultimate-destructive, catastrophic);
- preventing of material fissuring and breaking;
- assuring of the mechanical stability (rigidity of structural components), consequently maintaining the initial geometrical form of each component, during the entire process of operation;
- assuring the tightness of the technological areas.

Establishing the acceptable risk level for an oilduct represents a compromise between what the responsible structure agree to consider from the economical point, if the risk ocurring is taken into consideration, and the costs that have to be financial recovered, in case the risk was ignored.

But in practice there are situations when removing of all the unacceptable risks is not technically and/or economically possible, remaining some residual risks which could lead to major damages, with a probability that can not be omited. Elaboration and proving of a real strategy to prevent, limit and combat the effects of the major damages produced by residual risks at oilducts represent the objective of the risk management, a concept that implies:

- drawing up an adequate strategy for prediction and monitoring;
- a deep and rigorous investigation of all the accidents occurred at the respective or similar oilducts;
- conception, upgrading and applying of the intervention plans in emergency situations (the imminence of a major damage) or in crisis situations (arising of a major damage);
- drawing up and fulfillment of the personnel and population training plans in case of exceptional situation regarding the technical condition of the oilduct.

The above aspects could emphasize the following aspects in analyzing the technical risks of an oilduct [5]:

- identification of the risk factors involved in oleoduct operation and its disfunctions;
- identifications of possible scenarios (events succession) in cases of technical accidents;
- risks evaluation, meaning, on the one hand, estimation and quantification of the technical accidents consequences and, on the other hand, estimation of probability regarding their occurrence;
- risks hierarchization and their including in “negligible”, “acceptable” and “unacceptable” categories;

- setting up the methods, means and procedures to remove the unacceptable risks and identification of residual risks;
- management of residual risks.

The dangers due to the petroleum transport through oilducts represent the inputs for risk evaluation. The main dangers which could occur because of the petroleum products transport through oilducts are caused by inflammability and toxicity of these products, in case of their accidental leaking and spreading in the environment. Inflammability mainly implies safety aspects and toxicity implies aspects regarding environment. A fire could also put in danger some species of animals or could damage historical or archeological sits.

Relative risk assessment is used in order to identify or confirm the maximum risks areas. Also, the relative risk assessment is used as method for designing changes and in operational practices.

The following factors are taken into consideration when the total risk is assessed:

- the products features transported through oilduct, including the chemical, physical properties and toxicity;
- potential dangers (fire, explosion, toxicity etc.);
- the most vulnerable points on the route (crossing of the waters, pumping stations, surfaces under construction, taps etc.);
- the danger level as a result of product volume in the uncontrolled oilduct segment, the pressure in the oilduct segment, the period of time necessary to isolate the oilduct and the temperature scale of the environment;
- leaking velocity and the dimensions of areas where the product is spread, taking into account:
  - the type of product transported through oilduct;
  - the water flows (rivers) where the leaked product could arrive, having feeders with high, medium or low debit;
  - penetration of the leaked product into the dry or wet land;
  - condition of humidity or drought;
  - variations of wind, temperature and other climate factors;
- the response plans and procedures in case of emergency (including those for communication and other dangerous conditions) for personnel and equipment mobilization;
- disponibility of emergency services, including the specialized personnel, the protection and safety equipment and communication possibilities;
- health, safety and consequences on environment generated by the oilduct presence in areas with dense population.

Conclusions

The following objectives must be fulfilled in order to assure a continuous operation of the oilducts, at the designed parameters, in safety and technical security conditions, based on the modern maintenance system:

- reducing the aggressiveness of the pumped fluid by using the corrosion inhibitors and avoiding, as much as it is possible, the aggressive environments on the oilduct routes;

- implementation of advanced material and technologies coming from research activity, applying to the manufacturing procedures and the steel quality the oilduct is made of, as well as to the welding and assembling technologies;
- permanent improving of the designing standards, codes and procedures, taking into account the external action of forces or bad weather;
- training and improvement of the involved human resources, in order to avoid incorrect operation procedures;
- drawing up of some modern monitoring, detection and diagnosis systems and setting of some databases in order to find out the exact increasing velocities of the faults "lack of material" type, produced by corrosion;
- development of new methods, procedures and tools for technical diagnosis having non-destructive character and upgrading the actual ones;
- promotion of the preventive and predictive maintenance systems to oilducts, in detriment of corrective maintenance that involves more costs;
- necessity to run periodical inspections and permanent in situ monitoring of the technical oilduct condition, in order to have a rational schedule of the maintenance works;
- necessity to introduce some modern procedures within the management of oilduct maintenance, of Fitness for Service type;
- necessity of using the most performing equipment and the newest technologies in the oilducts field in order to perform the maintenance works at a high quality standard;
- necessity of checking the technological solutions chosen for every maintenance works, in order to emphasize their effects on the mechanical resistance of the oilducts;
- necessity to see the evolution of all the factors that establish the oilducts reliability and security, during the oilduct designing, setting and operation process, as well as necessity of strictly observe the applying of all the technical provisions and imposed technologies;
- observing the mechanical criteria of technical security for oilducts, in order to assure a high level of their reliability and technical security;
- necessity to establish the acceptable risk level based on an economic optimum between the costs of security studies and devices and those associated with occured accidents consequences etc.

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Unele probleme privind monitorizarea, diagnoza, mentenanța, fiabilitatea şi securitatea tehnică/tehnologică a oleoductelor

Rezumat

Articolul prezintă câteva aspecte legate de acțiunile de monitorizare in situ şi de diagnoză tehnică, necesare supravegherii parametrilor de procesare ai oleoductelor, detectării/diagnosticării defectelor şi intervenției rapide în cazul producerii avariilor prin aplicarea operațiunilor de mentenanță, în vederea menținerii unui nivel înalt al fiabilității şi a funcționării în condiții de securitate tehnică a oleoductelor. Sunt enumerate şi propuse o serie de metode, procedee şi mijloace moderne de monitorizare, de diagnosticare şi de mentenanță, proceduri noi de evaluare privind aptitudinea oleoductelor de a fi utilizate în condiții de securitate tehnică precum şi avantajele utilizării acestora.

În final, sunt prezentate obiectivele şi direcțiile de acțiune viitoare necesare pentru o abordare modernă a sistemelor de speța oleoduct.