COMPRESSOR STATIONS PIPELINE SYSTEM INTERGRITY MANAGEMENT EUSTREAM, A.S.

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1. Introduction/Background

Company Eustream (Slovak Republic) is the biggest TSO (Transmission System Operator) of natural gas from among the countries of European Union. Company's transmission system is a part of the system supplying countries of Western Europe with natural gas from Russian Federation.

In its almost 40-years history Eustream has gained credit of safe and reliable transporter of natural gas with annual capacity exceeding 90 BCM, which represents more than one sixth of the natural gas consumption of the whole European Union.

Transmission system consists of pipelines with total length of more than 2.200 km with dimensions mainly of DN1200 and DN1400 and 4 compressor stations with total installed power of more than 1.000 MW.

Installed are the following power units:

- 6MW industrial turbines (producer 1. brnenská, Czech Republic)
- electro units with nominal output power of 25 MW (producer ČKD, Czech Republic)

Other used aeroderivates

- PGT 25 Nuovo Pignone and
- COBERA 6562 DLE (producer Cooper Rolls)

Currently we are in the process of installing 2 high-performance units PGT 25+ (producer GE) at our biggest compressor station in Veľké Kapušany.

2. Objectives of the paper

Based on the national Act on Energy, as well as in accordance with our own policy of Integrated Management System, Eustream is obliged to assure safe, reliable and efficient operation of transmission network. As one of the means for reaching this objective, we gradually started to systematically build complex system of assessment and management of risks connects to our transmission system several years ago.

From the aspect of the needs for maintenance and risk assessment eustream transmission system can be divided into three technological units

- **Transmission pipelines** – high-pressure transmission pipelines delimited by launching and receiving pigging chambers at compressor stations
- **Compressor technology** – compressors of different power, age, producers and their adjacent components
- **Compressor station pipeline systems** – consists of collector pipelines, connection and other above-ground and underground technological pipelines, and the great number of different types of armatures. This area can be delimited on one side by transmission pipelines launching and receiving pigging chambers and on the other side by air compressor machinery.

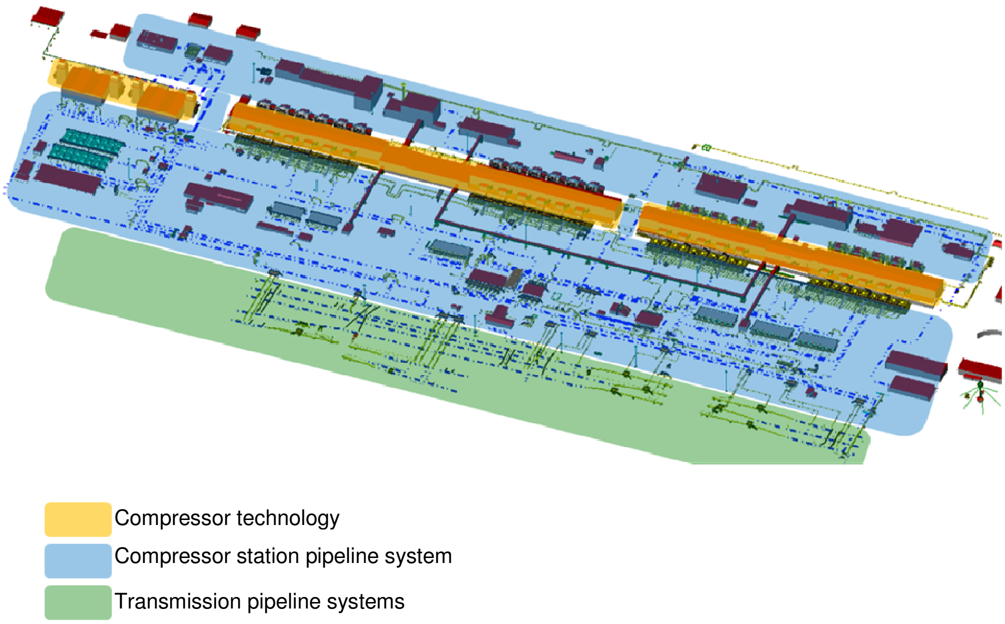


Figure 1. Three basic technological units of Eustream transmission system

From the aspect of risk management Eustream has implemented at its transmission pipelines system of Pipeline Integrity Management in accordance with requirements of ASME B31.8S.

For monitoring of reliability and safety of compressor stations and their components we have implemented principles of Reliability Centred Maintenance (RCM) and its implementations to SAP/PM module.

Eustream compressor stations are in their extent, number of armatures, pipelines length and total installed power of turbocompressors unique. Issue of risk management at pipeline courts, forming the third technological unit of the transmission system, is extremely complicated. It is also due to this reason why no risk assessment system has been implemented for these technologies. Compressor station pipeline system thus mean today the riskiest place in the process of implementation of Total Integrity Management in the whole transmission system. Moreover, gas pipelines at compressor stations make up complicated technological network of criss cross above-ground pipes, which at each station reach total length of 25 to 30 km. Their common critical characteristic is that they are non-inspectable by internal inspections (non-piggable) and high density of individual assets in small closed space also obstructs efficiency and reliability of outer inspections, or successful application of No Pig method.

To the complicated character of risk assessment at the compressor stations areas adds also the fact that they were build gradually along with rising number of transmission lines and according to increasing needs for transmission capacity of the whole system. This has resulted in today's parallel existence of different technologies located at the stations – ranging from those built in 70´s to the new pipeline court parts.

Figure 2. Compressor station 02, Jablonov nad Turňou

Figure 3. Pipeline systems at the compressor station

3. Development/Methods

3.1. Basic risk elements of compressor stations pipeline systems

Integrity management of metal gas pipelines is usually based mainly on information from internal inspection, but the problem occurs in the case of non-inspectable metal pipelines. One of the ways enabling one to replace the missing information from internal inspection and how to assess pipeline condition is the method of corrosion assessment - ECDA (External Corrosion Direct Assessment), described in NACE RP0502-2002 recomended practice. Eustream, with regard to its know-how in the area of transmission pipelines integrity management, does not assess conditions of pipes at compressor stations only from the aspect of corrosion, but extends integrity management by other factors. In integrity management of non-piggable pipelines at compressor stations Eustream identified the following risk elements:

- corrosion protection
- placing of pipelines in space and quality of used materials
- dynamic phenomenons at compressor station pipeline systems
- third parties intervention

3.2. Corrosion protection

Decisive factor decreasing safety and reliability of pipeline systems is corrosion destruction of steel pipelines.

At Eustream compressor stations pipeline systems there are pipes which can be divided, according to their placement in corrosion environment, to above-ground and underground. They are protected against corrosion in passive and active manner.

3.2.1. Passive corrosion protection

Above-ground pipelines are protected against corrosion by organic coatings – paints. As these kinds of pipelines can be easily checked and re-painted we consider them corrosion safe.

Underground pipelines are placed in water and soils conditions. They are protected against this aggressive corrosion environment by passive way of coating – insulation. During initial phases of compressor station construction polyetilene tape insulation was used directly at the site.

About ten years ago we have started solving critical points from the aspect of corrosion damage in a systematic way.

3.2.1.1. Mud discharge piping

Parts of compressor station pipeline networks were mud discharge pipes (blow down manifold) with diameter of 38 x 3 mm. They were placed at the bottom part of individual pipelines, mainly under the level of ground water. At mud discharge pipes, due to the small thickness of the material, the highest probability of corrosion damage occurred. Therefore it was decided that these pipelines had to be removed (in total 90 pieces at 4 compressor stations).

Figure No. 4. Decanting pipeline

3.2.1.2. Ground-air passing

Pipelines at the place of passing from ground to the air are exposed to extreme differences in the conditions of aeration. It was at this points where local failures of coating and pitting corrosion occurred.

Ground-air passings in areas of compressor stations were step by step repaired and instead of original sheet polyethylene insulation a new two-component polyurethane insulation was applied. This correction was made to the depth of around 1 meter. After sand blasting of pipes at the point of ground-air passing a polyurethane insulation material was applied to the height of around 0.3 m from the ground and was subsequently painted by protective coating preventing damaging of insulation by UV radiation. In total about 1800 passings were repaired.

Figure 5. Original and repaired insulation at the point of ground-air passing

3.2.2. Active corrosion protection

In 2002 a research project named "Active Corrosion Protection of pipeline networks at compressor stations" was elaborated and executed. Based on the level of detected corrosion risks of pipeline systems the best suitable form of active cathodic protection was proposed. Task was, in its pilot form, executed at compressor station in Jablonov.

Task was divided to the following phases:

A) detection of technical components condition limiting application of cathodic protection

B) detection of corrosion threat on gas pipeline network located in the ground

- analysis of localized corrosions focused on finding out their reason and extent
- determination of corrosion soil agresivity within the complex of compressor station

C) summarization of available background documentation on comparable solutions realized abroad

D) feasibility study for cathodic protection at compressor stations

- summarization of a) to c) phases outputs
- proposal for the way of active corrosion protection at compressor station 02 and evaluation of brought benefits

E) development of the project, realization of trial construction, 3-months trial operation.

Task was completed by construction of cathodic protection; total 6 cathodic protection stations were built at pipeline court.

Basic construction elements of anode earthings used at the compressor station are FeSi segments with weight of 50 kg. The way of placing was done in few variations. Due to existing bedrock in the area of the compressor station No. 2 and its surroundings use of vertical anodes in the depth exceeding 10 m was as a possibility fully excluded. Optimal depth for placing of segments, based on the data obtained by geological research, is in the depth of approx. 1.8 to 8 m, where clay layer of soil is located. This fact was also conformed during construction. For improving transfer resistance between anode and surrounding soil coke pack was used with all anodes. To 300 mm diameter drills 6 anodes were placed to depth of 6 meters and 50 anodes were placed to drills in depth of 3 meters. In one anode placing inserted were 2 pieces of FeSi anodes to 6m deep breasted drills. Other anodes are horizontal. In total 166 FeSi anodes were installed with total weight of 8 300 kg.

As the pilot project results were positive, construction of cathodic protection at other compressor stations was implemented in 2006.

Figure 6 to 9: Photos from construction of active corrosion protection at the compressor station

As an example we provide description of cathodic protection at KS 04:

- 3 kiosks for cathodic protection stations. Each kiosk contains 2 sources of cathodic protection. This means there are 6 sources available in total working independently with their own circuit: source-anode-pipeline and so cathodic protection is secured by 6 stations of cathodic protection.

- 1 x anode grounding from R65 rail welded to a shape of a comp with length of 65 m.
- 5 x distributed anode grounding. In total there are 97 FeSi (á 50 kg.) placed in horizontal depth of 1.5 to 2 m.
- 6 x testing (metering) sonde MS 110 for automatic management of cathodic protection sources
- 14 x MS 200 + metering object for metering of cathodic protection effectivness.
- 19 x galvanic anode + metering object. Magnesium anodes are placed in places out of cathodic protection range and where construction of further SKAO would not be effective. Average value of switching potentials at pipelines protected by galvanic anodes is -1, 10 V.

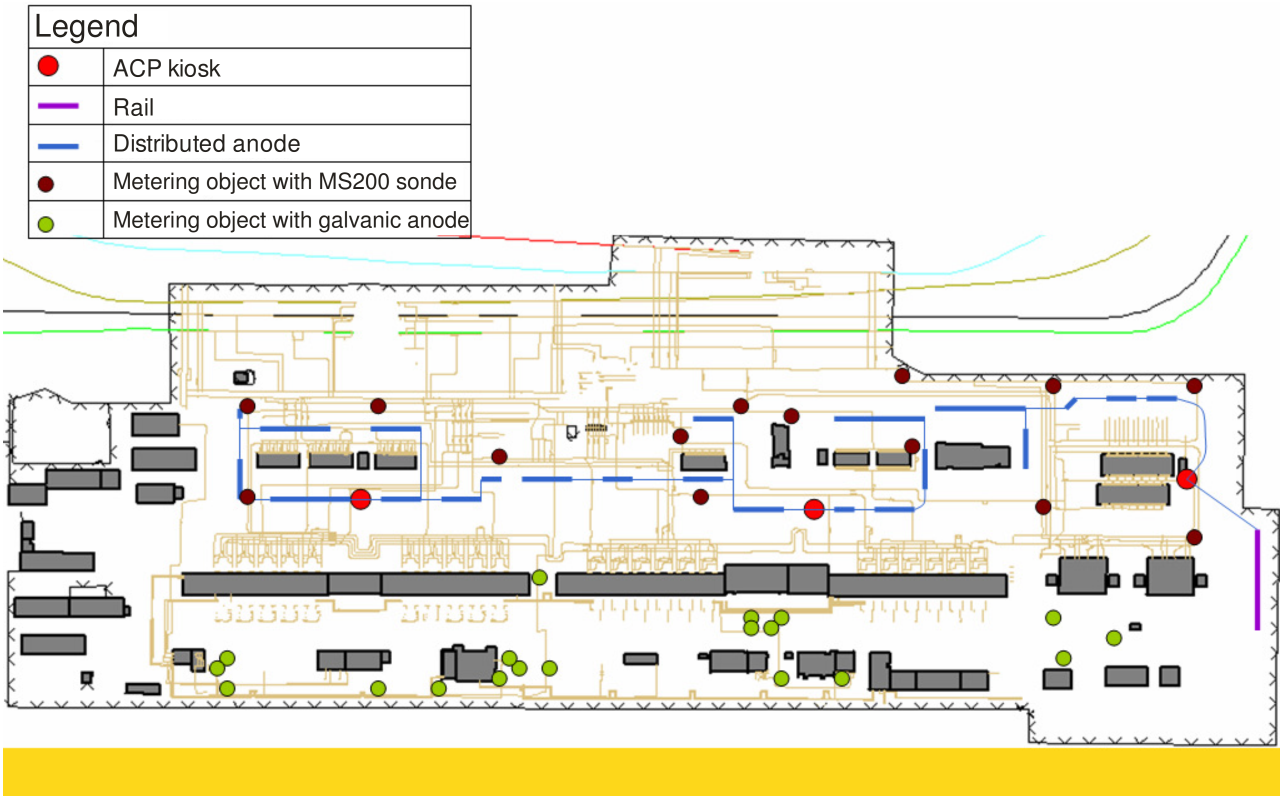


Figure 10. Arrangement of cathodic protection equipment in complex of CS 04 station

3.2.3. Casings repairs

In general, metal casings have negative effect on cathodic protection. In case of short circuit – galvanic connection with pipeline casings takes away protective current from cathodic protection and the pipeline near to the casing remains unprotected.

Since 2003 up to 2008 repairs of selected steel casings (total of 22 casings) were proceeded at all compressor stations in the form of their replacement for concrete U prefabricates.

Repair helped to remove the following defects:

- insufficient pipeline coating (insufficient adhesion of tape insulation, formed sacs), unmaintained technological process of tape insulation during construction (overlapping of layers and by that created corrosion defects)
- surface corrosion material loss at the place of casing front
- deformed casings
- centering loops galvanicaly connected with the body of the casing and the pipeline

Figure 11. Casing condition after excavation

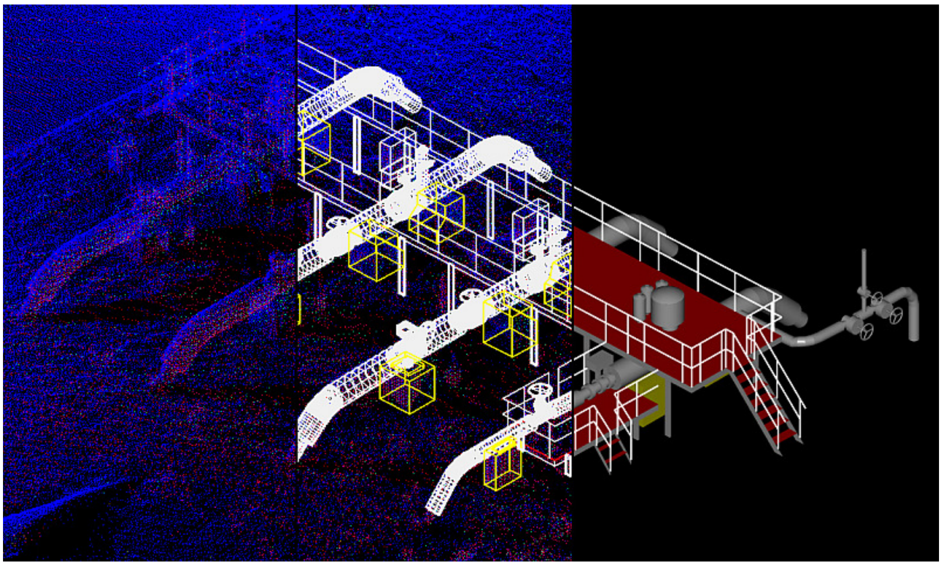
Figure 12. Repair of casing by replacing it with concrete prefabricate

3.3. Placing of pipelines in the space

Spatial information of the compressor station pipelines positions, which is stored in GIS, is the part of crucial data. GIS provides data on localization of pipelines, mainly those locating underground pipes, ground-air passings and similar. In Eustream we were aware of the importance of information on the localization of pipelines, or risk arising from not-knowing their precise localization. In 2006 we initiated the project for precise mapping of all gas pipelines position at the compressor stations.

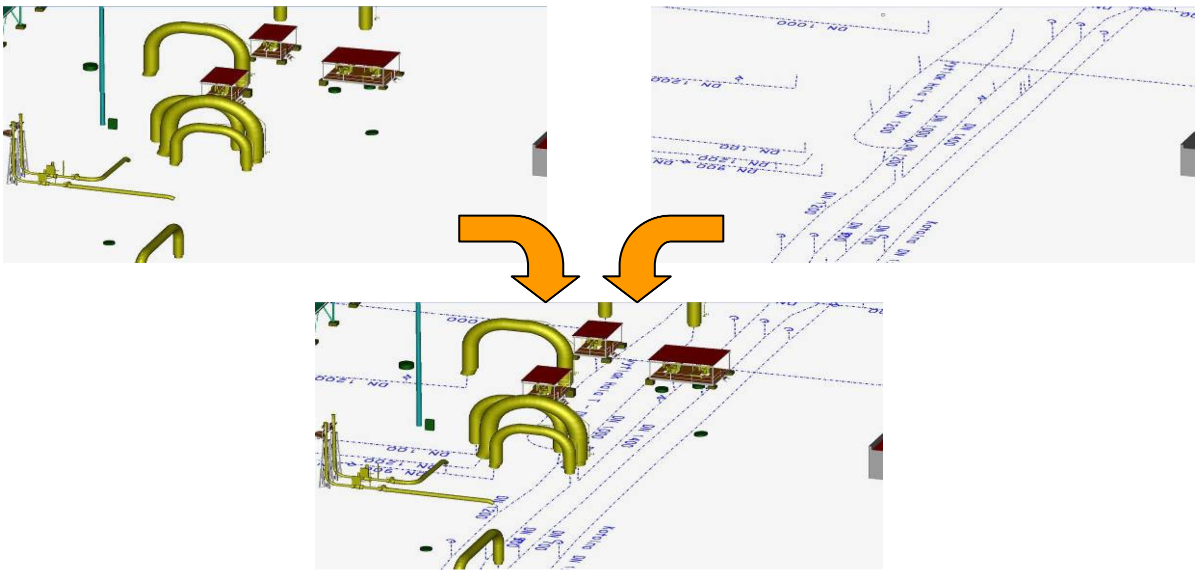
The whole process comprised from the following steps:

- Mapping of above-ground parts with the help of laser scan method

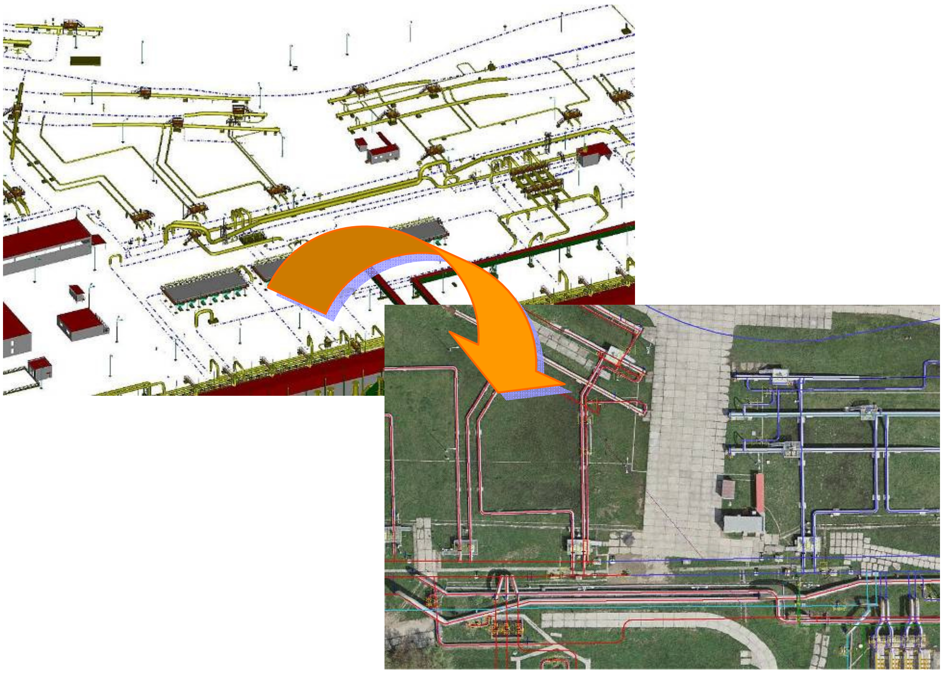


- Staking out of underground pipelines and their precise geodetic localization

- Connection of partial results to one unified 3D model



- Update of GIS spatial data based on 3D model



Such updated spatial data is one of the basic and important data for creating model of risk on compressor station pipelines systems.

3.4. Dynamic phenomenons on compressor stations pipeline systems

Unlike transmission networks placed continuously in the ground in terrain, gas pipelines of compressor stations are exposed to different dynamic pressure phenomenons, which have an impact to their lifetime and reliability.

Dynamic phenomena, which affect gas pipelines at the compressor stations, occur in connection with their complicated construction – great number of turnings and armatures concentrated in small space as well as in connection with constantly changing operation conditions and heat dilatation. Many vibrations are caused by unbalanced rotors of turbo units, aerodynamic powers, pressure oscillations and other dynamic effects.

One of the dynamic values, which are specified for compressor stations, is heat of flowing gas, which in extraordinary cases, may reach 80℃ at exit point.

Similarly also various pressure levels influence safety and reliability of compressor station pipeline components. Different pressure levels are at suction and discharge, significantly lower pressure levels are in supply pipelines for powering of turbine and for heating.

Dynamic pressure phenomena have the biggest effect on above-ground pipelines. Their placement in the ground damp these pressure powers and thus monitoring of their effect outside the compressor station complex is irrelevant.

The consequences of acting of these phenomena could be many times easily observed, they caused vibrations at various frequencies and amplitudes. Therefore we paid great attention to identification of such phenomena, discovering their causes and their subsequent removal or mitigating of their effect. Majority of these tasks was realized in cooperation with specialised expert centres. Negative consequences of acting of these phenomena were paid a great attention and they were given real scientific base. We in Eustream solved several tasks focused dynamic pressure phenomena. This document contains the most important ones.

3.4.1. Flexible bearing of pipeline components

During first phases of construction of gas pipelines at compressor stations above-ground components were placed in welded metal saddles. As a result of many years effect of dynamic pressures and vibrations, damages started to appear in the places of pipeline saddle fixings.

Similarly, we also identified problems at places of pipeline placement in concrete corbel structures and at numerous places we measured high values of locally accumulated residual pressure.

This led to a fact that after 2000, that is after 30 years of operation of the oldest parts of gas pipelines, the project on investigation of the scope and extend of damage was initiated. Several sources, which could result in serious damage and emergency, were discovered.

- shortcomings of pipeline placement in supporting saddles where fatigue of material was discovered in the places of weldings,
- shifting sittings of pipelines, where by an influence of so-called pitting ovality and forming of small holes occurred which caused changes in the height of pipeline placement,
- operational vibration accompanied by movements in placement and dynamic elements of powers active on supporting structures, to anchor plates and pillars. This caused loosening of anchor plates from concrete pillars and also in damaging of concrete pillar objects.

To repair of placement of pipelines a special approach was elaborated. Pipeline was placed on wooden temporary arrangements according to so-called complex process of installation and with simultaneous control of reaction power and height setting of pipeline centre-line with stress to local re-arrangement of the place of the support. Grinding-off of welded saddles was followed by installation of the new saddle supports with belting, under which higher heat resistance textile-rubber tapes were inserted. Belting with rubber-textile support secures limitation of pipeline shell vibrations.

Redyst Vibro-insulation elements, consisting of STOP-CHOC metal spring parts, were placed between concrete pillars and the pipeline. Vibro-insulation elements in individual places of support were selected according to the size of reaction power in placement. Result of the reconstruction executed at the compressor stations was primarily placing of pipeline system with vibro-insulatuion. With the help of way of installation, according to vibro-insulation elements supplier instructions, and by control of reaction powers accumulated power bias voltages in the pipeline system were removed. At the same time necessary movability in individual places of support by inserting stainless steel metal spring with damping was secured, by which oscillation response was lowered.

Figure 12. Vibro-insulation supporting structures under foot of ball-valve

3.4.2. Setting of compressor management

This research task was focused on searching reasons of pipeline components vibrations. In between 1994 to 2002 we managed to identify exact reason for unwanted pipeline court vibrations in some 6 MW compressor units. The reason lied in resonance pressure gas oscillation in junctions of pipeline collectors of the halls. Analytical-numerological analysis shown that the reason of vibrations are pressure oscillation in T-bends woke by gas flow, which in certain speed and size conditions in critical place lead to significantly intensive periodical resonance acoustic (pressure) oscillations in blind (closed) pipeline junctions. Energy and amplitudes of these pressure pulses, related to so called Helmholtz standing acoustic vibes (blowpipe effect) are sufficiently big in order to make part of pipeline court to oscillate in the critical place. This effect is stronger in case of turnings of the same length (that is volumes with the same resonance acoustic frequency) arranged one to another on the pipeline which conducts the medium.

Research task states that initial cause of unwanted oscillation of pipeline systems of the first two halls at the compressor station is incorrect design document of these halls. Designer chose simple unified concept of pipes diameter that can be widely modified for connecting of compressors to levels of gas compression (i.e. with great number of junctions). He did not consider tendency of such concept (mainly with small number of compressors in operation) for self-awakening resonance oscillation. This mistake has not been repeated in the following phases of construction. Pipeline systems, in their concept, are designed in other way and compressors are always placed to a one level mode, which partially prevented fluid-acoustic resonance from occurring.

Analysis of oscillation causes was executed at compressor station No. 2, but quantitatively the cause of oscillation is similar also with other compressor stations (quantitatively critical frequencies at individual compressor stations differ as far as different lengths of pipeline collector junctions are concerned, but also other geometrical parameters).

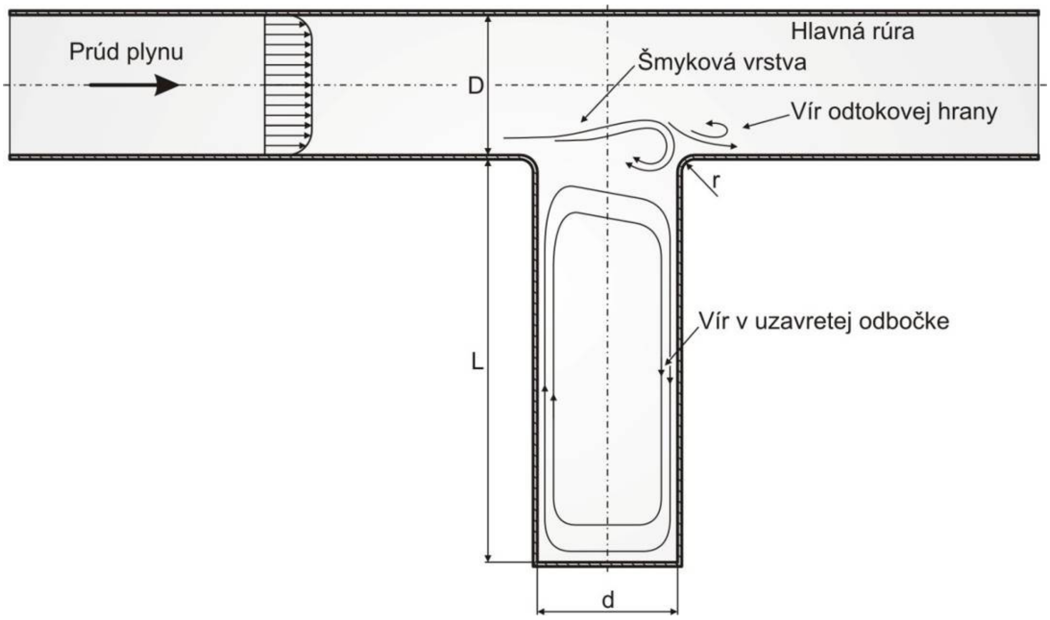


Figure 13. Pipeline branch as a source of pressure oscillations

Based on theoretical calculations places and conditions of occurrence of resonance oscillations were selected and subsequently tensometric metering was done confirming existence of these phenomena.

Subsequently a project of establishing such management of starting and shut-down of compressors was initiated that eliminates the mentioned phenomenon. This Project was made for those parts of pipeline systems at all compressor stations, which may experience resonance oscillation in blind junctions. Today this way of management is fully applied. Since its implementation there has been no unwanted oscillation of the whole part of pipeline system.

3.4.3. Dynamic pressure conditions in the places of T-bends

Placement of T-bends (junctions, T-pieces) is, from the aspect of occurrence of dynamic phenomena, which may cause cyclical stress of pipeline material, one of the factors which must be considered in risk assessment model.

From aspect of negative impacts it is possible to distinguish three groups of bends:

- horizontal connections to collector pipeline
- vertical connection of the branch to collector pipeline with arch
- combination of two and more connections in close distance, i.e. distance of maximum 5 m between individual axes of branching pipelines.

Examination of location of these bends in risk assessment model is important, because pressures to pipeline caused by powers of various directions in the place of pipeline connection are almost at the yield limit.

Horizontally connected pipeline is one which axe, at the point of its connection to collector pipeline, has angle of <45° towards the ground.

Horizontal branch makes pressure, caused by its dilatation to collector pipeline, which causes its arching in one or the other way at the place of connection. Collector pipelines are freely placed in supporting structures, which enable them free movement so the connections of horizontally placed pipeline does not create any unwanted phenomena. These occurre in the case that there are other connected pipelines in the distance less then 5 m making pressure oriented in other direction.

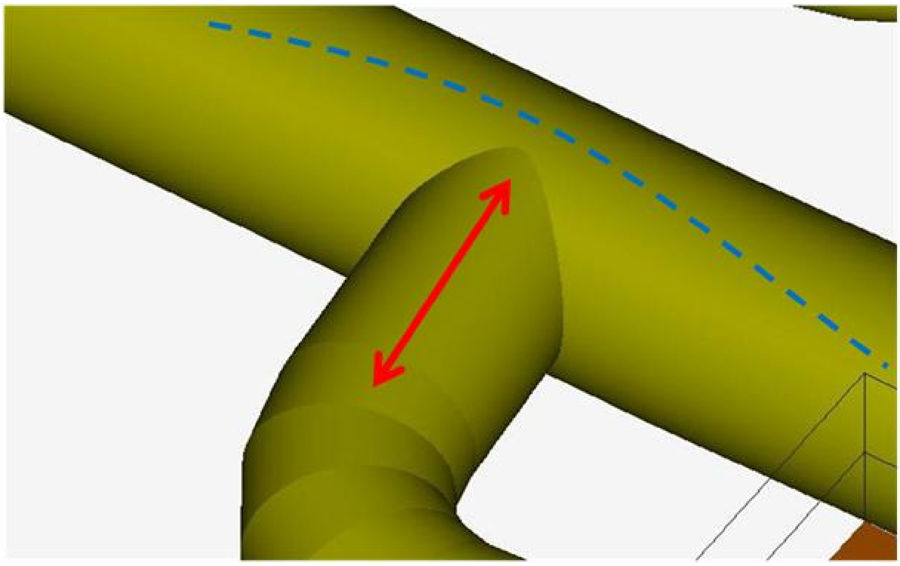


Figure 14. Horizontally connected pipeline

Vertically connected pipeline is the pipeline which axe in the place of connection to collector connected pipeline has an angle of <45° towards the ground.

Vertical branch comes out vertically from collector pipeline and continues with an arch, which turns it into the wanted direction. By heat dilatation, in the whole length of the arch, extension or shrinking occurs, which subsequently causes twisting pressure at the place of connection to collector pipeline. As bends are produced according to order they are made by forging. The pressure is acting at the place of welding between the bend and the collector pipeline pipe.

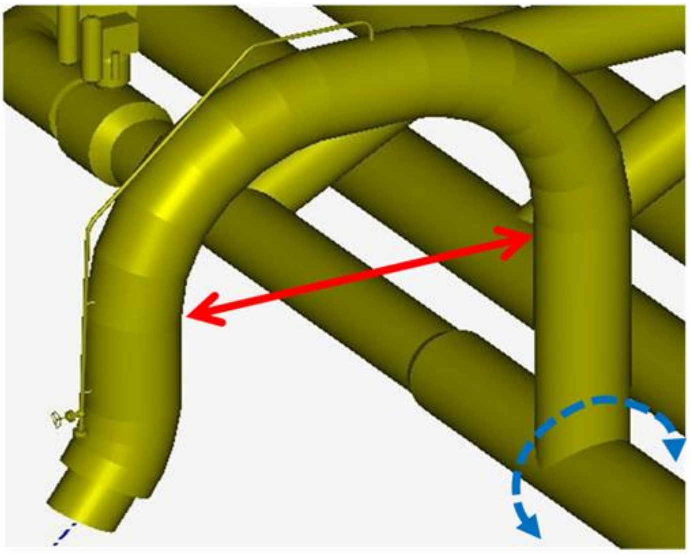


Figure 15. Vertically connected pipeline

As combined connections of pipeline are considered places where two or more branch pipelines are connected to collector pipeline. Mutual distance of axis is smaller than 5 m. Such branching pipelines cause various kinds of pressures to pipeline depending on its placement.

From the aspect of placement we distinguish three types of combined junctions:

- Two vertically connected pipelines located in opposite direction. With their dilatation they cause twisting of collector pipe between junctions.
- Combination of horizontally and vertically connected pipe causes the combined twisting pressure.

- Combination of two horizontally connected pipelines directed in opposite directions causes arching of collector pipeline between junctions to S shape.

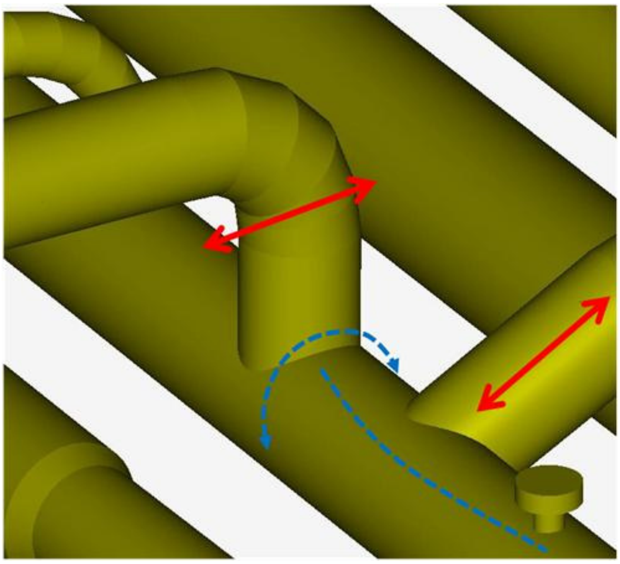


Figure 16. Combined junction

To enable also knowledge of intensity of above described conditions, there was implemented a project of metering them in real time. For that purpose, areas of pipeline system were singled out, where tensometric sensing units were installed. Technological system continually monitors the level of tenses recorded by sensors, while results are processes in a special database. The stored results of measurements can be reversely viewed and all events can be evaluated, which occurred during operation.

3.5. Intervention of third parties

Risk of damaging technological units of gas transmission grids by third parties (by suppliers and contract partners) is globally the most frequent cause of incidents.

According to the database EGIG (www.egig.nl) managing historical records of all extraordinary events on gas pipelines In Europe since 1970, third parties are responsible for 50% of all incidents in gas pipeline grids.

With respect to the aforesaid as well as with regard to the fact that sites of compressor stations are entered by a lot of workers of external suppliers as well as contract partners on daily basis to carry out various activities and services, our company had to create a system to protect safety of people and technological facilities.

Since 2007, Eustream has built a certified integrated Management System for environmental management, management of occupational health and safety and quality management according to the standards ISO 14001, OHSAS 18001 and ISO 9001, from which an obligation follows to control and to minimise risks as well as environmental aspects with suppliers and contract partners.

The above-mentioned process is managed as early as in the phase of selecting of supplier and further it continues in the phase of the very performance of works.

Before the selection of supplier itself, an audit is carried out at its place with focus on verification of capacity of supplier to meet requirements of our company on required degree of quality. Only those companies will get into a short-listed circle of suppliers, which possess necessary machinery and staffing provisions, procedures prepared to perform activities and a system of precluding disconformities introduced.

Before the very performance of works, employees of supplier organisations are retrained in basic requirements of our company in the area of occupational health and safety (BOZP) and environment. Performance of works itself can be commenced only based on approved technological procedure and a signed order to work. During performance of works, activities of suppliers are under supervision by operator, engineers of occupational health and safety and environment.

Having finished works, evaluation is prepared for each supplier, so that possible dissatisfaction in fulfilment of our requirements was reflected in tender procedures of suppliers in the future.

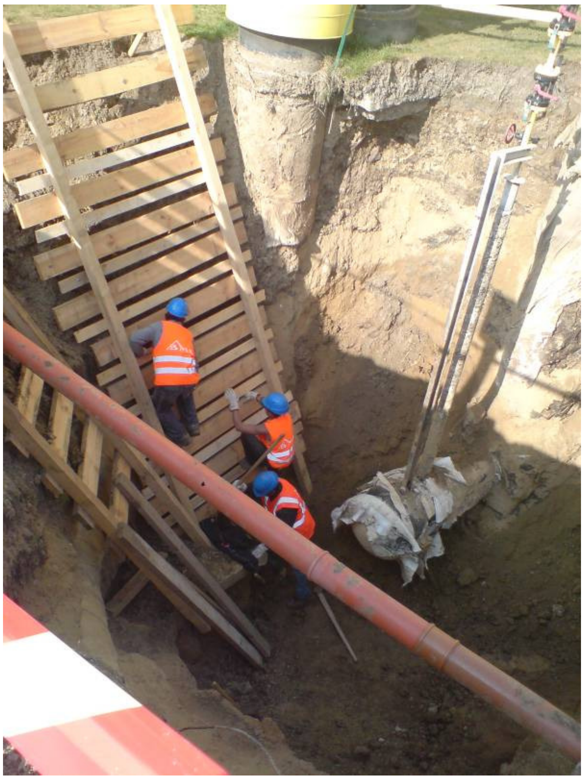


Figure 17. Works done by external company in the compressor station area

4. Results

4.1. Risk Model Building and its Management

At present the „best approach" that would be applicable for all pipeline systems and all situations does not exist. Therefore we had to take the flexibility importance into account when defining the risk assessment model. Making the integrity program draft it was necessary to harmonize a significant volume of information between the respective steps. The selection of an approach to risk assessment was dependent on what data sources and information related to the integrity were available. The risk model is not closed. Further data needs may be identified during the risk assessment procedure due to more precise assessment of potential threats.

Due to defined objectives and priorities of the company Eustream the method of relative risk index calculation was chosen to build the risk assessment model on pipeline compressor stations systems, as options of actual implementation of the model in practice.

Under the document Pipeline Risk Management Manual by W.K. Muhlbauer, the index approach to risk assessment requires to define groups of threats and consequences, and successively to set risk factors to each group. In the next step, to allocate numeric values (score) to each group and each risk factor contributing to the overall idea on risk. The given values include factors or variable increasing the risk, as well as elements decreasing the risk. In this way weights are allocated to each variable reflecting the significance of the factor in risk assessment. Allocating the respective weights is based on available statistics, international recommendations and engineering estimation in case the data are not available.

The project team primarily observed the requirements of the standard NACE RP0502-2002, defining the minimal range of factors, in their defining the suitable range of risk factors and classification of risk factor in groups, which have to be monitored and assessed to define the impact of corrosion on pipelines in the pipeline court. But the requirements defined by NACE deal only with the issue of corrosion impact on the pipeline and they do not treat other needs of Eustream to assess the risks, as e.g. impacts of stress conditions in the compression stations. It was therefore necessary to specify the potential threats in more details, to adapt their range and to enlarge them by further threats. Due to the high occurrence density of pipelines in combination with armatures on a limited space of the pipeline court also the results of adjusting the RCM of the company Eustream were taken into account in building the risk model for armatures.

The results of direct measurements of different gas distribution pipeline components at the compressor station focused on assessment of residual life-time of dynamically stressed pipes, considerations on suitable designed bedding, measurement of vibrations origin sources, examination and removal of corrosions on ground-air passing, construction of cathode protection and other activities were taken into consideration in building the risk assessment model to substantial extent.

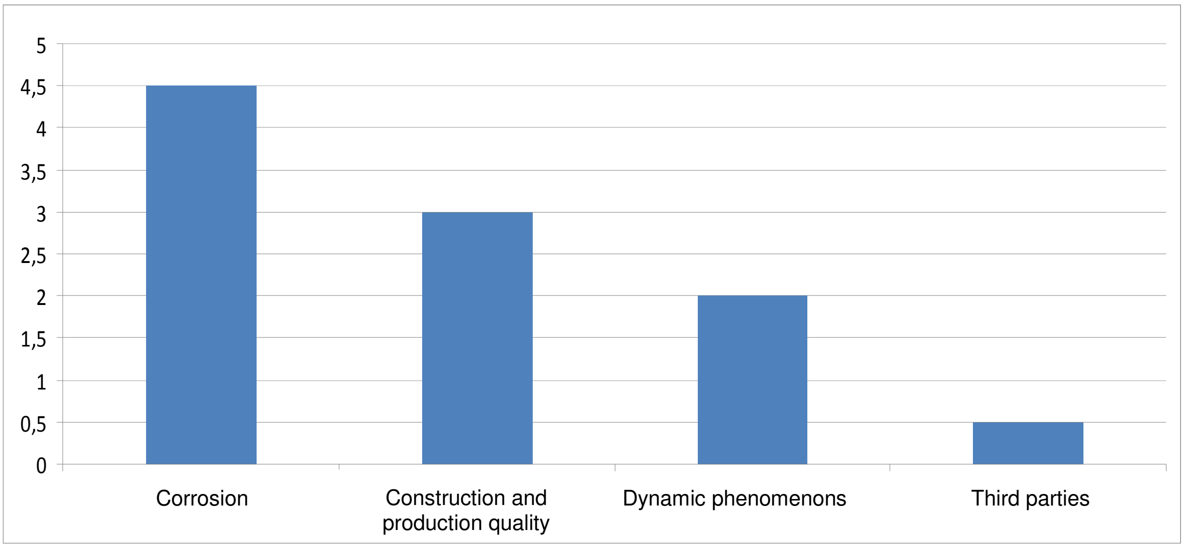


Figure 18. Relative indexes of basic risk elements groups

After the risk factors were defined, classified in groups and after the weight coefficients were set, the data sources were defined. In case that necessary data were not available to Eustream in the given time, the plans for their systematic collection were elaborated.

Eustream has got a defined mathematical model to calculate the risk on compressor station pipelines, identified existing and missing data sources, now. At present a systematic collection of missing data is going on. Further on we shall use the experiences and methodologies acquired in risk model implementation on transmission gas pipelines and in RCM implementation with turbo-compressor technologies.

The next step shall be to calculate the risk and to establish segments of pipelines by the risk level. Each calculated segment shall have its own risk rate and its location in risk matrix. The final risk matrix shall be divided into degrees being identical to degrees adopted within the RCM project. Identical degrees have been applied also in the project of risk assessment on the line part of the transmission network. In this way a compatibility of the results of individual solutions is provided – RCM with the compressors, pipeline risk with the transmission gas pipelines, and risk model with compressor station pipelines.

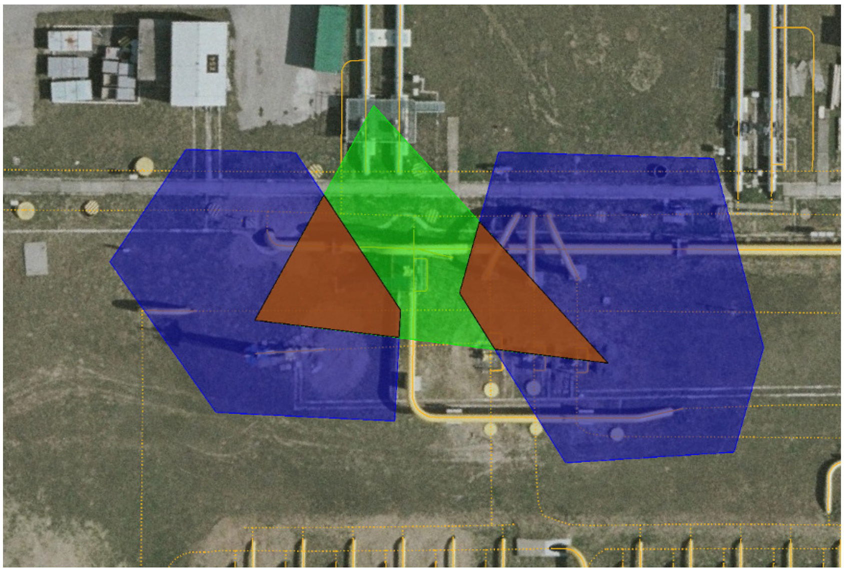


Figure 19.Principles of pipeline segmentation – putting of elements layers

Figure 20. Establishement of pipeline segments according on factors combination

The risks shall be depicted in form of a risk matrix and successively in GIS. Such a representation allows depicting the individual segments by the risk level and their spatial localization as well. The software support used to risk management in transmission gas pipeline systems shall be used to calculate and represent the risks on pipelines at compressor stations.

The risk management itself shall be realized using the same principles as in case of transmission gas-lines. Risk management shall be performed in following steps: analysis of the individual risk segment components, adopting remedy measures and the feed-back.

Within the risk segment analysis the segments shall be identified exceeding the acceptable risk rate. A risk drill down shall be performed, i.e. the respective risk components shall be identified, the most significant factors, or those that can be influenced by the remedy measures, so that the overall risk of the segment can be decreased in this way. It means that the segment shall be "shifted" in the risk matrix from the zone of non-acceptable risk to a lower position. The technology to present the risk factors and to analyze them has been already implemented in Eustream in the project on transmission gas-line risk modeling and it shall be used also with the pipelines at compressor stations.

The next step shall be the adoption and execution of the remedy measures. Risk management does not mean to "play with figures" only, but it has to be interconnected with the practice, i.e. with real mitigation operations at the objects of transmission network. RCM project defined the following risk levels and basic behavior rules towards the segments in which they were positioned:

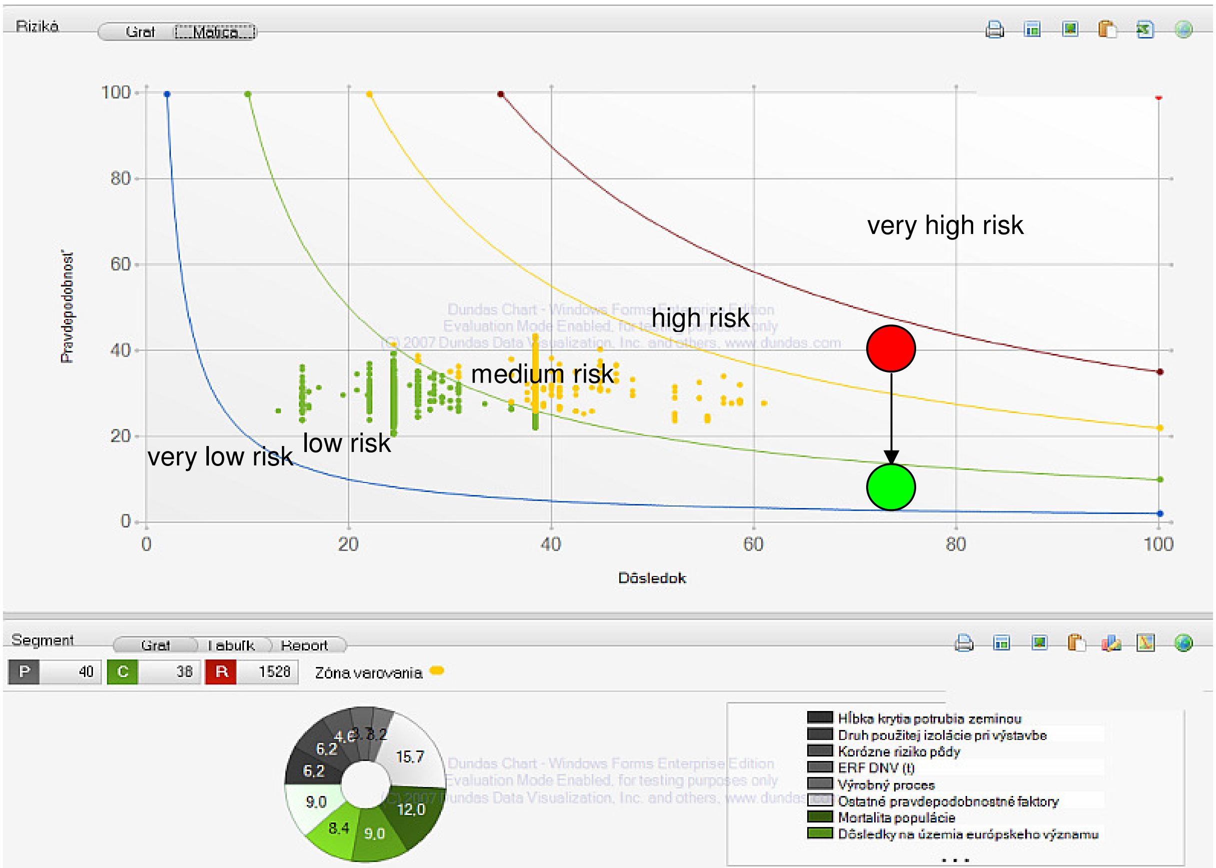


Figure 21. Segments representing in the risk matrix

Low Risk (LR) – the components of the equipment that are located in this area are at a risk level demanding regular and systematic visual control of the possible degradation. The visual control is usually a sufficient strategy. Too high allocation of financial means for the components of this risk level has to be well-founded not to waste the means. This type of maintenance is usually performed by the workers employed at the spot – usually it is called operator's maintenance – the 1st level maintenance.

Medium Risk (MR) - the components of the equipment that are located in this area are at a risk level demanding the technical condition of the equipment to be continuously controlled. Planned preventive maintenance based on time or traditional preventive maintenance of the 2nd level is a suitable strategy for this risk level.

High Risk (HR) - the components of the equipment that are located in this area are at a risk level demanding the technical condition of the equipment to be continuously maintained, monitored and controlled. Maintenance on the basis of the condition is a suitable strategy for this risk level. The activities of this maintenance are usually completed by maintenance activities on the basis of time and traditional preventive maintenance activities. But the technical condition of the equipment should be the decisive factor in making an order to work – maintenance of the 3rd level.

Very High Risk - the components of the equipment that are located in this area are at a risk level that is impossibly high and it is irresponsible to continue the operation in such a situation. These components of the equipment have to be adopted in a way to bring the equipment out of this risk situation. This kind of works is usually organized with the help of amendment projects.

After these remedy measures are applied, it shall be necessary to record the new situation in the information systems and to calculate new risk values. Within this step also the efficiency and effectiveness of remedy measures shall be identified. Re-assessment of the validity of the model used for the risk calculation itself shall be also part of the feed-back – it means the factuality of identified factors and their relative index values. The regular re-assessment of setting the limits of the respective risk levels/degrees shall be also important.

5. Conclusions

Operation and maintenance of non-inspectable pipelines means a great challenge fro each gas-pipeline operator. Eustream has been operating such gas pipelines in a complex technological environment of compressor stations. The internal inspection cannot be substituted by NoPig methods because of number of crossing lines, the used materials and dimensions of the pipelines.

Eustream aims to provide for safety, reliable and effective operation of the transmission network; our company has been using the existing know-how and at present it applies a system with non-inspectable pipelines which shall gather available relevant information on the pipeline and in form of calculating the relative risk index it shall provide for a complex overview about the pipeline. Such calculation combines not only the corrosion threat factor assessed by using the principles of NACE RP0502-2002 standard, but also the threat factor resulting from the construction technology and used materials, the thread factor resulting from the dynamic phenomena and the factor of threat caused by the third parties activities. The system shall use the risk management methods already applied and it shall become a compatible part of the transmission network operation management and maintenance management systems.