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NEW TEST METHODS OF NON-METALLIC PIPEWORKS FOR LIQUID FUELS

1. INTRODUCTION

Conformity assessment of non-metallic pipeworks for petroleum products and pipe fittings assemblies represents a nowadays issue both for designers, manufacturers, users and for the third party bodies which are involved in the certification or surveillance activities. This assessment is required as consequence of the explosion risk which exists and should be minimized having in view personnel life and health assurance, as well as to prevent environment or goods damage, and for a free circulation of goods when they satisfy the essential safety requirements on the European level. For the purpose of solving this issue, it must be had in view the requirements for manufacturing, certifying and usage in full safety conditions for the non-metallic underground petroleum pipes.

Testing and assessment of non-metallic pipes for liquid fuels for certification purposes is mainly important having in view the explosion risk which exists and that should be minimized to assure personnel life and health, to prevent environment or goods damage, as well as for a free circulation of goods when they satisfy the essential safety requirements on the European level.

2. GENERALITIES REGARDING EXPLOSION PREVENTION AND PROTECTION

Explosion prevention and protection have a major importance for personnel safety and health, because explosions put in danger both life and health of workers due to the uncontrolled effects of flames and pressure (hot radiations, flames, pressure waves, particles

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spread out), due to the presence of toxic reaction products and oxygen consumption in the air that should be breathed. In order for an explosion to occur the condition of three factors simultaneously meeting in the same space and time: the flammable substance in form of vapors, gas or mists; or powders; presence of a oxidizing substance (air or oxygen) as support for the violent combustion (explosion) and the presence of an ignition source in form of a spark (of an electric or mechanical nature) hot surfaces etc. (Fig. 1).

If a dangerous explosive atmosphere is possible be formed, certain explosion protection measures are required, in order to prevent forming of dangerous explosive atmospheres, avoid ignition of dangerous explosive atmospheres or diminish explosion effects to ensure workers health and safety.

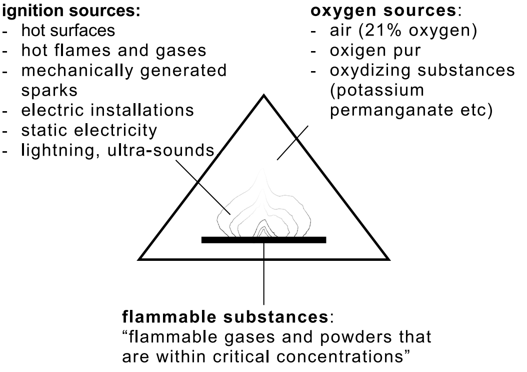

Fig. 1. The Ignition Triangle

It should be of first priority dangerous explosive atmospheres prevention. This can be achieved by the following: using of replacements for flammable substances, limited concentrations, inertising and prevention or limitation of explosive atmospheres formation around equipment or installations.

If it is not possible prevention of dangerous explosive atmospheres, ignition should be avoided by protective measures that avoid or mitigate probability of ignition sources occurrence. It should be estimated the probability of a simultaneously occurrence of a dangerous explosive atmosphere and an ignition source in the same place so the extent of the required protective measures can be accordingly determined.

Every time this is possible, the explosive atmosphere should be prevented. Thus, the first step in explosion risk assessment is to determine if an explosive atmosphere may appear and in which circumstances, and then it should be set out if this one can be ignited.

3. SAFETY REQUIREMENTS TO PREVENT FORMATION OF AN EXPLOSIVE ATMOSPHERE AND AVOIDANCE OF IGNITION SOURCES ON NON-METALLIC PIPES

The combustible vapours emitted by the liquid fuels in the atmosphere may form and explosive mixture. This is the reason why it is necessary for the pipework systems to comply with the essential safety requirements regarding explosion danger. These requirements have in view, on one side, prevention of an explosive atmospheres formation around the pipework by preventing leakages at the jointing points, and on the other side prevention (avoidance) of intrinsic ignition sources of the explosive atmosphere, as, for example the static electricity.

A safety issue in this matter occurred when the non-metallic pipework systems developed superior performances compared to the metallic ones. Corrosion on the metallic conduits, as well as the danger of stray currents (dispersion, run type) are two valid arguments in favor of using non-metallic pipes (made of plastics and rubber) in installations for conveyance of petroleum products in the petrol-chemical industry, in the fuel distribution and storage stations, and other industry fields.

In order to prevent explosive atmospheres occurrence, all pipeworks (the conduits and the jointing elements) must fulfill the following requirements: withstand to foreseeable pressure regimes; fulfill their function without significantly alter the properties under action of the fuel conveyed (to be compatible with the transported fuel). The manufacturers must provide all details regarding influences of different fuels on the materials that could affect the installation integrity; to provide a proper resistance to fuel permeation through materials, in order to limit the amount of vapors that is transferred to the environment. In order to ensure the allowed limits are not over-passed, tests of permeability to petroleum fuels must be carried out; they must support all the strains they are subject to, during storage, transport, installation and operating of the system. The significant tests should include traction, crush, torsion, impact and bending and to prevent static charges accumulation.

Taking into account the theoretical considerations regarding formation, accumulation and discharge of static electricity, a series of protective measures can be defined, and they may be applied according to case, to prevent the fire or explosion danger, as follows: earthing, use of adequate materials, antistatization of materials, choosing the proper constructive form (surface, distance towards the conductive elements earthed, thicknesses of the non-conductive materials); avoiding of dangerous rubbings (limitation of conveyor belts speed or the flow speed through conduits); environment conditions (high humidity), usage of charges neutralizers.

The main factors which determine the level of electrostatic potential generated during fuel flow within conduits are: fuel's electric conductivity, flow speed, conduit material, existence of some particles or immiscible phases as for example, water. Also, existence of narrowing, filters along the path can influence the level of electrostatic charge.

4. STANDARDIZED TEST REQUIREMENTS FOR NON-METALLIC UNDERGROUND PIPES

The standard SR EN 14125 specifies the requirements for underground pipework systems used to convey combustible liquids and their vapors from the petroleum products storage stations, as given the minimum performance requirements within the aimed goal, for safety and environment protection, and it applies for: transfer pipes to dispersion tanks where there is a positive pressure, vacuum aspiration and siphon; filling conduits from the fuel trucks to tanks; vapor recovery and venting conduits, secondary containment conduits; connectors.

According to this standard, to certify the pipework systems it is necessary to follow laboratory tests (type tests): Electric tests: tests regarding determination of electric capacity; tests regarding determination of transverse resistivity (volume resistivity); tests regarding determination of superficial resistivity (of surface); tests regarding determination of dielectric rigidity; Tests of resistance to fuels: test of compatibility with fuels; test of permeability to fuels; test of deformation by absorption of fuel; Mechanical tests on pipes: crush test; bending test for verification of the allowed bending radius; shock (resilience) test; piercing test; traction test; Positive hydrostatic pressure, negative (vacuum) and cyclic pressure.

4.1. Hydrostatic pressure test

All the pipes and connecting joints (so mounted to form one or more assemblies with a length of 375 mm or three times the outer diameter, whichever is the greatest value) are previously conditioned at (50 ±2)^{o}C and are tested for at least 5 minutes at the pre-established pressure, according to the pipe or jointing system type.

The inner pressure is then raised to reach the inferior test pressure specified for that specific application, and finally the pipes are checked for leakages. The same test procedure applies at a temperature of (23 ±2)^{o}C. If necessary, the pressure can be raised up to occurrence of an anomaly, leak or damage.

4.2. Vacuum test (– 0,9 bar)

This test is applicable to pipes and jointing elements for aspiration by depression after sample conditioning in air at a temperature of (23 ±2)^{o}C for at least 16 h. Each sample is voided at an internal pressure of (–0.9 ±0.05) bar [(0.1±0.05) bar absolute] after which the sample is insulated from the vacuum pump and it is maintained at least for 30 minutes at a temperature of (23±2)^{o}C. The inner pressure is noticed and the inner and the outer part of the sample are examined before and after dismounting to notice possible signs of sample destruction or damage.

4.3. Cyclic pressure test

This test applies for pipes and jointing elements for positive pressure, after their conditioning in water at a constant temperature (21.5 ±3.5)^{o}C for at least 1 hour.

Each sample is submitted to a cycle of pressures between a minimum of 1.0 bar and a maximum of 4.0 bar over the environment pressure, for 1.5 × 106 cycles at a rate not lesser than 25 cycles per minute and the environment temperature of (21.5 ±3.5)^{o}C and the samples are inspected for leaking at the end.

On the basis of studying the norms and standard requirements, there have been carried out three test procedures for pressure testing (hydrostatic, depression and cyclic pressure test; fuel compatibility and permeability test), mechanical tests (crushing, bending radius, shock-resilience, piercing, traction) and electric tests-static electricity (electric capacity, transverse resistivity, superficial resistivity and dielectric rigidity), procedures that form the basis of their implementation in the laboratory's quality system having in view extending its capacity of testing and assessment of conformity for non-metallic underground pipework systems for petroleum products.

Taking into account analysis of the safety requirements and laboratory tests above presented, as well as the test procedures carried out according to the European standards, a technical documentation has been carried out for the purpose of setting up a set of stands for pipe testing to hydrostatic and cyclic pressures, vacuum test. These stands ensure exigency in verifications for the requirements provided in the standards SR EN 14125 and SR EN13463-1.

5. TEST STANDS

For tests to hydrostatic and cyclic pressure the hydraulic stand shown in figure 2 has been conceived. It consists in the following sub-assemblies: SGIP – pressure pulses generation system; PH1 – manually operated hydraulic pump; PH2 – electrically operated hydraulic pump; RR – regulatory relay; RP1 – regulator of loading pressure; RP2 – regulator of discharging pressure; RM – diaphragm reflector; TP – pressure transducer (digital manometer); M1, M2 – analog manometers 1 and 2; R1, R2, R2', R3 and R4 – cocks; EV1, EV2 – electric valves 1 and 2; RA1, RA2 – water tank; RPF – pressure fine adjustment.

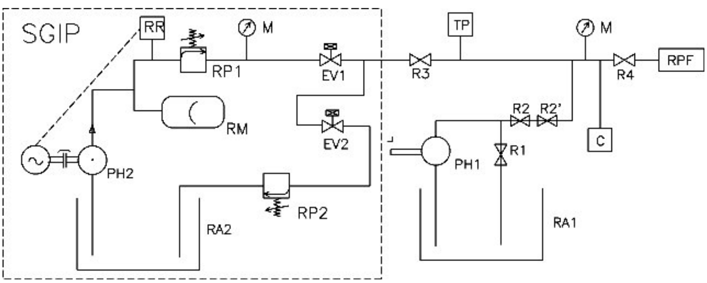

Fig. 2. Test stand for hydrostatic and cyclic pressure – hydraulic diagram

The hydrostatic pressure test is carried out for two thermal regimes: 23ºC and 50ºC at a lowest and highest test pressures between (+0.5 ±0.1) bar and (+30.0 ±1.0) bar, according to provisions in SR EN 14125:2005. Cyclic pressure test is carried out on pipes and pipe assemblies at a temperature of (21.5 ±3.5)ºC and a cycle of pressures of minimum 1,0 bar and maximum 4.0 bar over the ambient pressure, for 1.5 × 106 cycles having a rate of 20/25 cycles per minute.

With the help of a personal computer, for which software was conceived to processing, recording and displaying the test results, the following parameters can be entered: test duration, in minutes; measuring interval in seconds, for pressure; measuring interval in seconds, for temperature; in case of cyclic pressure test the total number of cycles can be entered – implicitly this is 1.5 × 106.

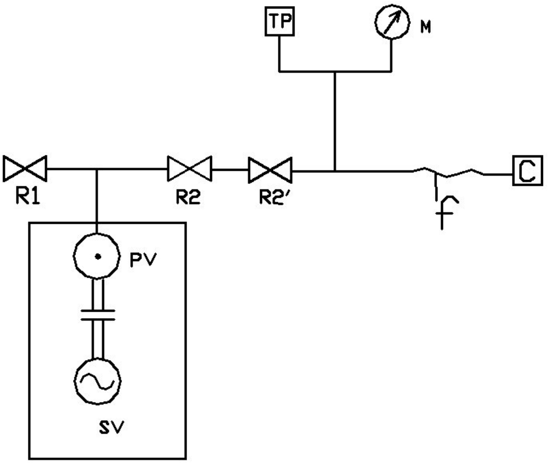

Fig. 3. Test stand for negative pressure – hydraulic diagram

The vacuum test stand for non-metallic underground pipes and their fittings is shown in figure 3 and it consists in the following sub-assemblies: SV – vacuum system; PV – vacuum pump; M – manometer; TD – negative pressure transducer; R1, R2, R2' – valves; f – high pressure hose; C – coupling.

The application to interface with the stand is similar to the application shown in the hydrostatic test stand and it is designed to pick data from the stand through connection to the serial port or a simulated serial port through a converter USB-RS232. The data received from the stand are current temperature and pressure; these can be saved and thus test evolving diagrams can be drawn.

6. CONCLUSIONS

Having in view the analysis of the safety requirements and the laboratory tests shown, as well as the procedures carried out according to the European standards, there had been carried out: the test stand for hydrostatic and cyclic pressure; the test stand for negative pressure; they are designed for verification of underground non-metallic pipes and their fittings.

These stands ensure verification of the specific requirements in SR EN 14125 and they had been carried out using the most modern elements to create and measure hydrostatic pressure and negative pressure, to maintain the test environment within constant temperatures range, to counting the number of applied cycles and the remaining ones; this having in view the fact that for the cyclic pressure test the stand must assure 1.5 × 106 cycles at a rate not lesser than 20 and not greater than 25 cycles per minute at a temperature of (21.5 ±3.5)ºC. Also, the stands are provided with an informatics system – software to process, record and display the test results.

The results obtained by using the included software can be used to display the information as diagrams throughout all test process.

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