Fuel Spills – An Automated Early Warning System

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Nature of Antarctica requires special protection in the areas of the Antarctic research stations, where available increased pressure on the environment from the winterers and stations means of life. In particular, one of the most dangerous sources of the possible pollution in Antarctica are welded fuel reservoir and a fuel pumping procedures. If the safety and standardization, including procedures of the fuel handling in Antarctica are the subject to the COMNAP Project "Oil Spill Contingency Planning and Equipment Survey" (Project Manager: Veronica Vlasich, Oversite Vice Chair: Mariano Memolli), then reliable operation of welded fuel reservoirs in Antarctica requires yet the standardization.

In 2007 the new fuel reservoir was installed at the Ukrainian Station Vernadsky with the 200 м^3 capacity. The new reservoir with double cylinder walls and bottoms was welded *in situ* from the manufactured at the factory bended components. The new fuel reservoir appearance is shown in Fig. 1, and special features of its design are shown in Fig. 2.

For additional preservation of the Station Vernadsky environment because of the new threat from the new fuel reservoir, authors team of this presentation has proposed the Project for a development of the automated early warning system of fuel spills possibility from the new reservoir. To solve this issue it is suggested the using, particularly, both the dynamics of technological defects development in the welds that were created during welding (such as lack of penetration, pores, cavities, cracks, undercuts) and the creation and development dynamics of new use defects (corrosion pits, blowholes, cracks) in the welds under influence of the variable natural disturbances] (wind, precipitation, humidity, temperature) and the statics concentrations of mechanical stresses in the metal and in the joints formed during electric welding. These defects have less mechanical strength than welded metal and when the critical volume defects in joints will be amounted, the mechanical destruction occurs resulting to fuel spills [1] (Fig. 3).

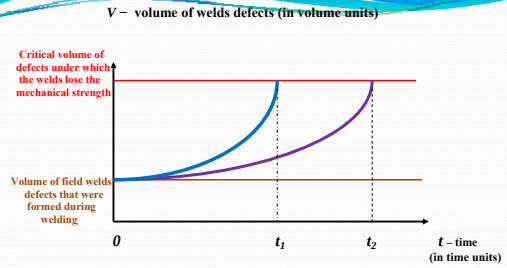

Figure 3. Dynamics of defects nucleation and development in welds during the reservoir operation.

t_1 – time of welds mechanical strength loss under reservoir construction vibration with resonance frequencies (and with greater amplitudes);

t_2 – time of welds mechanical strength loss under reservoir construction vibration with non-resonance frequencies (with a lower amplitudes).

In the Project such subsystems will be developed which will provide the reservoir of the "smart" quality:

* **Subsystem of determination and monitoring of critical, the most vulnerable to the destruction the reservoir welds and structural members by means of non-destructive testing equipment;**
* **Subsystem of determination the dynamics of the existing defects development in welds and nucleation and development in welds new defects, control defects volume and their concentration spectrum;**
* **The subsystem of the determination by means of the appropriate sensors set of amplitudes and frequencies of mechanical vibrations of critical structural members which may first lose mechanical strength;**
* **Subsystem of the mathematical modeling of mechanical vibrations reservoir construction during the short-time and long-time natural disturbances in Antarctica taking into account the dynamics of seasonal fuel fluctuations in reservoir;**
* **The subsystem of mathematical modeling of the dynamics of formation and development of welded joints defects during natural disturbances to determine the time of formation critical defects volume that can leads to loss mechanical strength of reservoir joints and structural members, that is for the early warning possibility of fuel spills;**
* **Subsystem of chromatographic analysis of air samples between the reservoir double walls to determine the beginning of the fuel micro-leaks from the indoor tank;**
* **Subsystem of the automation of the entire process of gathering and visualization of the functional condition information about welds and structural members of the reservoir using suitable sensors ; automation of the process of remote on-line control of functional condition of the welds and structural members of the reservoir, and the process of forecast and early warning prevent of the fuel spills possibility.**

Project of the development of such automated control system functional state of the welded fuel reservoir in Antarctica for early warning of the fuel spills possible is offered for the first time. Project is included in the State Target Scientific and Technical Research Program of Ukraine in Antarctica for 2011-2020.

To day the Project team made the following steps to develop the automated system:

* The experimental data analysis is made of welded joints fracture in oil reservoirs and in oil pipelines under Russia Far North conditions which are similar to natural Antarctic conditions. On this analysis base and on the base of new reservoir design documentation analysis and on the ground of the natural inspection *in situ* of new reservoir the potentially most vulnerable and welds and members were identified which require the priority monitoring;
* The three-dimensional model of the reservoir construction was developed , in particular, for the possible design upgrades simulation in response to the possibility of the reservoir mechanical strength loss;
* The analysis was made of the stability of the reservoir outer tank under Antarctic periodic kinematic perturbations (particularly wind, earthquakes);
* The methods and software were developed for the simulation of the frequencies spectrum of own resonance mechanical vibrations of the reservoir construction and its outer and indoor tanks which are especially dangerous for the welds mechanical strength;
* The nonlinear mathematical model was developed of the defects growth dynamics in welded joints under the field Antarctic conditions (particularly, the reservoir mechanical vibrations) to forecast of the joints mechanical strength loss.

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At the present day the work continues on the Project according with Request for Proposal (RFP) and the State Target Scientific and Technological Research Program of Ukraine in Antarctica in 2011-2020.

It should be noted the work being carried out by the Project team and our colleagues from the UK, Germany, Canada to obtain extra-budgetary financing of the Project from the International Science and Technology Center in Ukraine and to accelerate the development of automated system.

To give new impetus and quality in the proposed Project developing , to make use of the welded reservoirs operating experience at the others Antarctic Stations the Project team offers to our COMNAP colleagues to consider the following means:

* inclusion of the automated system development to the COMNAP Project "Oil Spill Contingency Planning and Equipment Survey" (Project Manager: Veronica Vlasich, Oversite Vice Chair: Mariano Memolli);

* COMNAP collaboration in the automated system development together with the Action Group on Antarctic Fuel Spills (AGAFS) SCAR;

* Developing an International Standard for additional protection of the Antarctic environment against fuel spills from welded tanks by means the proposed automated System.

Thank you for attention