УКРАЇНСЬКИЙ АНТАРКТИЧНИЙ ЖУРНАЛ
УАЖ № 8, 489-491 (2009)

UDK 612.015.4:612.39 (1-923.3)

ADDITIONAL MEASURES OF NATIONAL ANTARCTIC SCIENTIFIC CENTER FOR THE ENSURING OF THE ENVIRONMENT PROTECTION AT VERNADSKY STATION

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Abstract. In addition to the generally accepted constructive solutions in Antarctica to prevent fuel leakages from the fuel tank the development and the mounting are proposed of the automated control system of the tank functional state for the early warning of possible fuel leakages.
Such automatic system for control of the fuel tank functional state under the Antarctic conditions is proposed for the first time.
Key words: Antarctica Environment Protection, control automatic system, fuel leakages prevention.

Protocol on Environmental Protection to the Antarctic Treaty demands the execution of high international standards of the Antarctic environment protection. Especially Antarctic nature expects protection in the regions of the research stations location where there is profound effect on environment from investigator's life support facilities.

In particular one of the most dangerous sources of possible contamination of the environment in Antarctica are the fuel tanks both at the national stations and at ships that operate in Antarctica. Recognizing the importance of this issue, Scientific Committee on Antarctic Research (SCAR) recently establish the special Action Group on Antarctic Fuel Spills (AGAFS).

At Vernadsky Station the new fuel tank is installed which has replaced the old fuel tank of Station Faraday. New tank has the two cylinder design with capacity 200 m^3 and is welded in situ from stamped and bended components.

The tank functional condition is characterized by:

tensely-deformed state of internal and external capacities shells of fuel tank;

presence of the tensions (stress) concentrators at the internal and external tank shells that are caused by technology of the tank electro-welding from separate elements;

modal (natural modes and shapes) and dynamic (vibration) characteristics which are caused of constructional and technological conditions of the tank assembling. These characteristics also depend on external dynamic excitations such as wind, snow and ice loadings; seismic waves; daily and season temperature variations; season variations of fuel level in tank;

micro- and macroflaws topography in the tank construction which can lead to fuel leakage.

In addition to the generally accepted constructive approaches in Antarctica to prevent fuel leakage from the tank the development and mounting are proposed of the automated control system of the tank functional state for the early warning of possible fuel leakage.

This system of the on-line tank inspection will provide:

determination of the current values of modal characteristics, static deviation of the tank construction vertical and dynamical characters of tank construction elements under the exposure of the Antarctic external dynamic excitations; estimation of the stress characteristics and stability of the tank construction;

control of foundament vibration characteristics which are indications of the dynamic loading change on a tank construction;

finding and localization of the micro- and macroflaws and of tank construction damages which can lead to fuel leakage;

gas analyzer control of an air composition in the space between the tank capacities walls for the detection of fuel leakage from the internal capacity;

automatic acquisition and transformation of diagnostic information, visualization, processing and storage of diagnostic information for decision making about the tank functional condition.

For this purpose following develoments and scientific-technical elaborations will be undertaken for creation:

1. Vibro-diagnostics subsystem to define dynamic characteristics (vibration spectral characteristic) of the tank structural components and tank foundation, to inspect of theirs development and micro- and macroflaws appearance in the tank structure.

2. Subsystem of mathematical simulation for the analysis of the stability characteristics and tension of tank construction taking into account an influence of the real external dynamic disturbances according the measuring results in the vibro-diagnostics subsystem.

3. Acoustic emission subsystem to control of appearance and development dynamics of the tank damages.

4. Subsystem of gas composition analysis and control of air samples from the space between the tank capacities walls for the detection of fuel leakage from the internal capacity.

5. Automatic subsystem of acquisition, storage, processing, and visualization of diagnostic information about the tank functional condition at Vernadsky Station.

Proposed system will include such new features:

1. Integrated approach to the problem of the tank functional state control in Antarctic conditions which provide:

acquisition, analysis, and application of the information about the real tank structure vibration conditions;

development of the tank and its action mathematical model in real conditions of dynamic and static loading to define characteristics of tank durability and construction intensity;

information acquisition about tank damages development using acoustic emission inspection;

acquisition and analysis of the information about the tank foundation vibration state to define signs of dynamic and static loading changes;

information gathering and analysis of the air samples gas composition from the space between internal and external tank capacities for the detection of fuel leakage from the internal capacity;

automatic acquisition and diagnostic information transformation, visualization, processing, and storage for decision making about tank structure and prediction of its condition.

Data base produced by monitoring system during the first year of operation (when as inspected the fuel leakage is absent) allows to create a virtual image of the tank functional state at Antarctic conditions. During further system operation it will be possible to compare the initial virtual image with the image of current tank functional state. Difference between the initial and current tank functional state will tell about the possibility of the fuel leakage.

2. Use of the natural sources of the dynamic and static loading instead of artificial ones.

3. Such approach and developed system will lend to tank the new quality of “sensible” (“smart”) what foresee on-line automatic acquisition and processing information about tank functional condition.

4. For the first time the static and dynamic loadings on the tank construction in Antarctic conditions are taken into account which can cause changes of tank functional state.

5. The tank dynamic model will be developed for the first time. This model gives possibility to

determine current characteristics of the tank and the tank foundation, to display tank characteristics and theirs changes, and predict tank state on the field climatic and dynamic loadings.

The dynamic model development foresees:

acquisition and processing of the on-line information from transducers placed on the tank;

visualization on the computer monitor of the tensely-deformed state of tank shells with a denotation of areas of the tensions concentration and possible areas of the cracks rice in the tank shells;

simulation of the tensely-deformed state and the tank dynamic behavior under the periodic winds and seismic loadings;

determination of the tensely-deformed state of tank shells from the daily and seasonal temperature differences and seasonal difference of fuel level in the tank;

simulation of possible engineering decisions for operative modification of the tank construction with the purpose of estimation of decisions efficiency.

The team of development investigators and engineers is intended to obtain such Results:

1. Scientific Results:

1.1. Amplitude-frequency characteristics will be investigated of acoustic emission transducers which made from different materials and transducers directional diagrams; correlation will be studied between different manners of tank breakdown and monitored parameters under the Antarctic conditions.

1.2. New methods will be developed of vibration signal analysis, determined and studied diagnostic features of the fuel tank functional condition.

1.3. The dynamic model of tank will be created on the basis of information about the real oscillation state of both tank foundation and construction.

1.4. Current descriptions of stability and tensions of tank construction will be determined, the changes of these descriptions will be found out and the tank dynamic state will be forecast in the real operating conditions of the climatic and dynamic loadings in Antarctic Region.

2. Technical Results:

2.1. Acoustic emission methods will be improved for tank structure inspection, new acoustic emission signal transducers will be developed. The acoustic emission inspection method will be spread on Antarctic conditions.

2.2. New inspection and control subsystems will be developed for integrated control of the fuel tank functional condition at Vernadsky Antarctic Station.

2.3. Multi-channel automatic integrated system will be developed for control of the fuel tank functional condition at Vernadsky Antarctic Station.

3. Commercial Results:

3.1. Results of the automatic control system development of the fuel tank functional state at Vernadsky Station will be presented at Antarctic Treaty Consultative Meetings, at Meetings of Scientific Committee on Antarctic Research and will be recommended for application at Antarctic Stations of other Antarctic Treaty Parties as the necessary component (as International Standard) of the fuel-oil safe storage and handling systems in Antarctic Region.

3.2. The developed automatic control system of the functional state of a fuel tank will be offered also on commercial basis (or on the basis of mutually beneficial collaboration) for application at Antarctic Stations of Antarctic Treaty Parties in a complex with designing, making in Ukraine of fuel tanks and delivery theirs in Antarctic Region and with assembling and installation of the automatic control systems by means of Ukrainian experts and organizations.

For out-of-budget funding of the indicated system the Full Form (Request for Proposal) was developed in accordance with the procedures of international Science and Technology Center in Ukraine (STCU). Nowadays the international audit of the Full Form has been carrying out. Relevant Letters of Support were already received from British Antarctic Service (BAS), Committee on Antarctic Research and the Canadian Polar Commission, Alfred-Wegener Institute for Polar and Marine Research.