Global Journal of Engineering and Technology [GJET].
ISSN: **2583-3359** (Online)
Frequency: Monthly
Published By GSAR Publishers
Journal Homepage Link- https://gsarpublishers.com/journal-gjet-home/

Development of a non-equilibrium thermodynamic system for monitoring and blocking freon leaks in cryogenic equipment with a number of its monitored points up to 24 and a number of objects up to 100 units on the company's website and assessment of implementation in the European market

By

Vlastopulo.V.I[1], Lukashenko. A.V.[1], Tsaprika. E.S[1]

[1]Harvard Marine Research and Production Company LCC. Odessa, Ukraine.

Article History

Received: 01/08/2025
Accepted: 06/08/2025
Published: 08/08/2025

Vol – 4 Issue – 8

PP: - 01-04

Abstract

To date, a reliable and inexpensive system for monitoring and blocking freon leaks of cryogenic equipment with a number of monitored points up to 24 and the cryogenic equipment objects themselves with a capacity of up to 2 kW per 1 square meter of area has not been developed or produced. Its effectiveness in preventing fluorocarbon leaks to the environment in the carbon dioxide index has not been assessed. We have proposed the use of the automatic carbon dioxide index tracking parameter for any type of industrial cryogenic equipment produced and used in the European Union.

Keywords: *monitoring blocking freon leaks cryogenic equipment.*

Introduction

The use of freons in cryogenic equipment causes irreparable harm to the environment and destroys the ozone layer of the Earth, contributes to global warming and climate change, which is now observed by every inhabitant of the Earth. The European Commission has adopted a number of directives on a significant gradual reduction in the use of freons in cryogenic equipment, the transition to other less aggressive neutral gases and their complete use in the European Union by 2050 [1,2]

The most effective way is smart systems for monitoring freon leaks, which occupy 15% of all freon leak monitoring methods on the market. But their share is steadily growing. This work is devoted to the development of an effective system for monitoring and blocking freon leaks for multi-point cryogenic complexes in supermarkets, cryogenic warehouses, on mobile transport (road, rail, river, sea) and the assessment of its effectiveness in the EU market. The implementation of this system is also interesting in other markets of Asia, India, China, Russia, South America. The reliability of operation of this system is the main factor. In this connection, the real conditions of the nonequilibrium thermodynamic system for monitoring freon concentrations in the air under each measured point were included in the calculation and program, depending on the functions of the flow path and cross-functionals of the arrays of neighboring measured points[3,4]

Problem formulation

The use of a freon detector involves using it at a given point. In our case, an air flow is supplied to the gas analyzer from a number of micropumps, which periodically turn on and suck air from a given point or low-temperature volume into a common polymer line leading to the gas analyzer. This is a model of a nonequilibrium thermodynamic system [5,6] with different ways of delivering the sucked-in air volume. The concentration is determined by the detector and it is displayed on the screen of the monitoring site of this cryogenic equipment with duplication of the results on the telegram channel. If, for example, 10 ppm is exceeded during 3 cycles, the system signals the blocking of freon flow into this low-temperature volume.

Their changes show the intensity for each concentration relationship and for 2 functional or their sub functional have the form:

$$P_1 = f_1 (E_1 , E_2)$$
$$P_2 = f_2 (E_1 , E_2)$$

Differentiating among the equation, absolutely the outcome will be:

$$dP_1 = A_{11} dE_1 + A_{11} d E_2$$
$$dP_2 = A_{12} dE_1 + A_{12} d E_2$$

*Corresponding Author: Vlastopulo.V.I

The system also has a monitoring backup detector, which is turned on when an array of incorrect values of the main gas analyzer is detected. The calculation of these arrays is also carried out using a system of equations for a nonequilibrium system. Subsequently, the incorrect gas analyzer is replaced by a cryogenic company.

There are simple and cross-sectional coefficients of connections between singles structures of state and interactions of structures under distribution of arrays of freon concentration data under adjacent low-temperature. Basic and cross coefficients A in the form of corresponding functions of various functionals E:

$A_{11} = f_{11}(E_1, E_2)$

$A_{12} = f_{12}(E_1, E_2)$

$A_{21} = f_{21}(E_1, E_2)$

$A_{22} = f_{22}(E_1, E_2)$

Calibration of freon detectors was performed according to its passport and taking into account the equations of thermodynamics of a nonequilibrium system with the functionality of the arrival of a flow of sucked air from a given point of monitoring freon leaks. There can be up to 24 such points and each point has its own display on the company's website. The number of measured multi-point equipment can be up to 100 units. Such networks can be supermarket networks with low-temperature volume complexes, refrigeration equipment warehouses, networks of mobile refrigeration transport, auto, rail, river, sea.

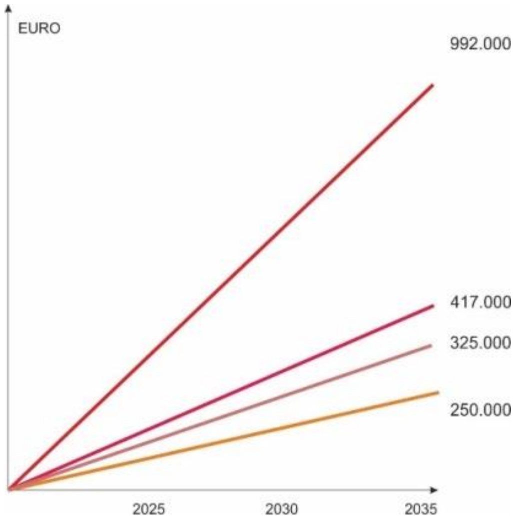
The efficiency of the application was assessed:

1. By the cost of average statistical freon leaks in supermarket chains, low-temperature complexes for frozen products.
2. By reducing the cost of maintenance by cryogenic service companies.
3. By average statistical fines in the European Union for excess consumption of fluorocarbons or their leaks.
4. By the cost of quality losses of frozen products.
5. By reducing energy losses for the operation of cryogenic equipment.
6. By the number of tons of freon leaks or the carbon dioxide index.
7. By increasing the number of people living in urbanized areas or cities in Europe.
8. By increasing the area of urbanized areas of human habitation.

As a result of 3 years of using 10 systems in metro supermarkets and in Ukrziznytsia Ukrainian Railways, when 1 complex of low-temperature volumes of up to 16 units leaks, up to 200 kg of freon leaks at a price of 500 UAH, which is 100,000 UAH, there are 300 such units in Ukraine, on average, it leaks once every 3 years. In other words, on average over 3 years, 100,000 x 100/50 euro exchange rate = 10,000,000 UAH / 50 euros (Grivna exchange rate) = 200,000 euros. About a quarter of this number are leaks with independent freon supply, although their number of supermarkets is about the same. That is, 50,000 euros. In total, with a number of supermarkets up to 500, the cost of freon leaks over 3 years is 250,000 euros. Approximating to 2030, the cost of leaks by the end of 2030 is 417,000 euros. Approximately up to 50,000 euros are annual losses in the condition of frozen products. That is, by the end of 2030, approximately 250,000 euros. Savings in maintenance and repair by cryogenic service companies are approximately 65,000 euros per year minus SMBFL cost. That is, by the end of 2030, it will be 325,000 euros.

That is, by the end of 2030 total losses are 992 000 euro.

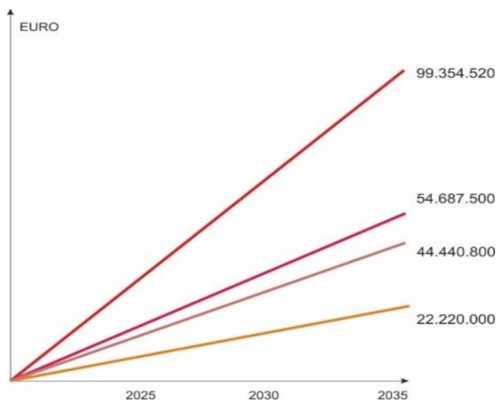
Graph of cost reduction for maintenance of low – temperatures freon complexes in Ukraine.



1- Losses from freon’s leaks,
2- Losses from losses of condition of frozen products,
3- Losses from losses of technical service and repair minus SMBFL cost.
4- Total losses.

Graph of cost reduction for maintenance of low – temperatures freon complexes in Euro union without taking into account the transition from freons to carbon dioxide and propane.

Taking into account the cost of freons in the European Union of approximately 50 euros per 1 kg and the number of supermarkets up to 14,000, the losses may be as follows, without taking into account the transition from freons to carbon dioxide and propane.



*Corresponding Author: Vlastopulo.V.I

1- Losses from freon's leaks,
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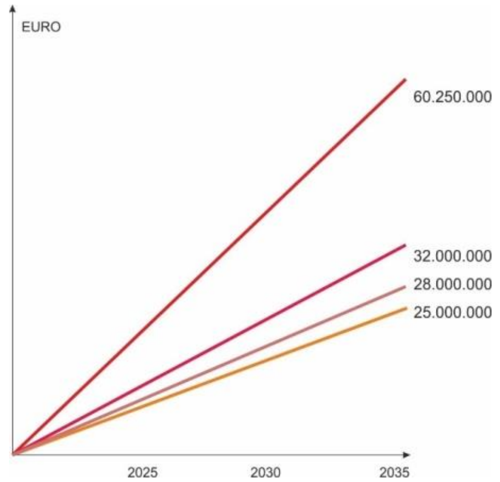
3- Losses from losses of technical service and repair minus SMBFL cost.
4- Total losses.

Graph of cost reduction for maintenance of low – temperatures freon complexes in Euro union with taking into account the transition from freons to carbon dioxide and propane.

On average, maintenance and technical repairs per supermarket per year amount to 10,000 euros x 1,000 supermarkets can be reduced by 40% and this will amount to 4 million euros.

The typical U.S. grocery store spends about $101,900 every year on all equipment repairs and maintenance, says the report. One third of that budget—a whopping $33,900—goes to the refrigeration trades. (HVAC and general repairs tied for second place with each eating only 9% of the total spend).

It makes sense. Today's groceries have more refrigeration equipment than ever before and maintaining that cold chain is critical for food safety and customer trust. But the bulk of these service calls are for repairs, not maintenance. According to the report, the average store calls their refrigeration repair service 36 times a year. Even worse, half of those calls are emergencies, requiring a faster turn around and an even higher price tag.



1- Losses from freon's leaks,
2- Losses from losses of condition of frozen products,
3- Losses from losses of technical service and repair minus SMBFL cost.
4- Total losses.

In all, only 11% of the total repair and maintenance budget goes to actual preventive maintenance. Yet proper maintenance is the best way to avoid disruptive operational failures and expensive repairs. Running dirty cooler cases costs money in four ways.

Conclusion.

1. Developed calculation model of a nonequilibrium thermodynamic system for monitoring and blocking leaks of the front of multi-point cryogenic equipment with the functionality of sucking in an air flow from under the measured point and cross-functionals of adjacent measured points has been developed to determine the state of correctness of measurements of the working gas analyzer.
2. Failure to use the System for monitoring and blocking freon leaks in low-temperature volumes in supermarkets or similar ones will increase freon emissions into the atmosphere. With a quantity of 10,000 supermarkets, approximately 40% with a centralized freon supply and almost every 3 leaks, and it leaks quickly, freon is a heavy gas and falls to the ground. That is, the entire complex of 16-24 low-temperature volumes loses 200-300 kg of freon, with an independent supply, a low-temperature volume loses 20 kg of freon. In total, only in European supermarkets, losses are approximately 100 tons annually. By 2035, this will be 1,000 tons, taking into account the introduction of new cooling systems on CO2 and propane, losses can be reduced to 700 tons. Taking into account the aggressiveness of freons, the global warming index of CO2 can amount to 2,100,000 tons of CO2 emissions into the atmosphere.
3. The method must be certified in the automatic control system of refrigeration unit parameters as a direct continuous method for measuring freon leaks with an accuracy of 1 ppm.
4. Primary energy savings caused by the project, in GWh/year. 2 kW x 24 hours x 365 days x 0.85 power losses due to freon leaks x 15,000 supermarkets x 0.2 coefficient of losses from the total number of supermarkets =44 676 000 KWh/ year + 100 kW x 24 hours x 365 days x 0.85 power losses due to freon leaks x 3,000 low-temperature warehouses x 0.2 loss coefficient of the total amount low temperature warehouses = 446 760 000 KWh/ year. Total: 491 436 000 KWh/ year or 491, 436 GWh/year. Final energy savings caused by the method, in 0, 000 49 GWh/year GWh/year.

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*Corresponding Author: Vlastopulo.V.I