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STUDIES AND RESEARCH ON MAINTENANCE OF REFRIGERATION EQUIPMENT

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Abstract: Bibliographical studies carried out for the maintenance of refrigeration equipment have an important role both in industrial and domestic use. Refrigeration equipment does not have the same indices of exploitation after a certain number of hours, thus, their technical condition is worsening due to multiple causes. It thus occurs the need to conduct maintenance (corrective or preventive) by which the equipment is restored during a well-defined time. Maintenance reduces equipment stagnation and Freon pollution. The purpose of this paper is to study and deepen the knowledge of the types of maintenance used in cooling devices, together with the reliable ones, to extend the life of refrigeration equipment produced or enhance its operating efficiency.
Keywords: *maintenance, refrigeration equipment, technical status, reliability.*

1. INTRODUCTION

Nowadays, refrigeration systems have an important role both in industrial and household appliances. Those fitted with refrigeration equipment firms are:

- water coolers;
- compressed air coolers;
- air conditioning;
- industrial refrigerators and freezers;
- household refrigerators;
- refrigerated cabinets and showcases;

Through these devices, namely refrigeration equipment, one obtains the artificial cold, which contributes to slowing or arresting the biological changes, physical and chemical in foodstuffs. This action is maintained as long as food is kept in determined conditions of humidity and temperature. The purpose of these refrigeration devices or equipment is to decrease or maintain temperature at a lower level than in the environment. [1]

From a technical point of view this equipment requires maintenance, but larger companies neglect maintenance of this equipment. Therefore, after a while this equipment fails or is damaged.

Consequently, from the technical, economic and ecologic point of view this equipment requires maintenance.

2. CURRENT SITUATION IN THIS FIELD

At least two bodies participate always in the cooling process: the body cooled (evaporator) and the body performing the cooling, called refrigerant.

The classification of installations producing artificial cold is generally made on the following criteria:

- working principle;
- type of refrigerating cycle;
- frequency.

According to the operating principle, the refrigeration installations used in industrial, commercial or domestic applications can be of three types [2]:

- Mechanical compression refrigeration system: uses the elastic properties of the gases and vapors that are manifested by increasing their temperature during compression and the decrease of the temperature during the expansion process;

- Thermo-chemical absorption or compression installations: their working principle is based on the successive performance of thermo-chemical reactions of the working agent by an absorbent followed by desorption of the agent from the adsorbent. The absorption and desorption processes thus play the role of suction and discharge processes performed by mechanical compressor. Thermo-chemical compression is achieved by using a binary mixture, consuming the heat;
- Ejector equipment: uses the kinetic energy of a jet of vapor or gas. Depending on the construction of the nozzle and the operating process, this equipment may be with ejector or vortex.

2.1 Refrigerants

To enable cyclic functioning of refrigeration installation, thermodynamic agents take over the heat through vaporization and give away the heat through condensation at low temperatures or close to ambient, so it must be characterized by some particular properties that distinguish them from other thermodynamic agents from other type of installations.

In terms of chemical composition, Freon, which is fluorohydrocarbon, may be divided into three broad categories:

- CFCs (clorohydrocarbon), classical Freon, containing Cl which is very unstable in molecule;
- HCFC (Hydrochlorofluorocarbon), Freon called transition, which contains hydrogen as well in the molecule, due to which Cl is more stable and does not decompose so easily under UV radiation;
- HFC (hydrofluorocarbon), considered Freon of final substitute, which does not contain any Cl atoms in the molecule.

In assessing the impact of pollutants, rules were introduced for their removal from service and the introduction of alternative refrigerants. (Kyoto regulations) [3]

Figure 1 presents the main refrigerants used currently and gives solutions to replace pollutants (CFCs and HCFCs generally at a lesser extent).

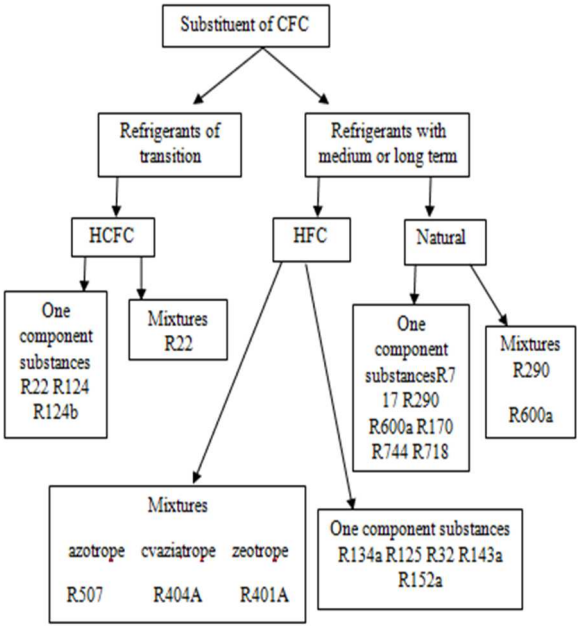

Fig.1 Layout of Freon and new substitutes

3. FAULTY FREEZERS

It is generally considered that the refrigeration system works properly when noticed the following [4]:

- frosted suction pipes to compressor flange; it shows that the evaporator is well supplied with liquid, which makes the vapor still be wet at the evaporator output and saturated at the aspiration in the compressor;
- compressor discharge line is hot (it indicates that the vapors aspirated by compressor are neither wet nor overheat);
- no beatings are heard inside the cylinders.

But the presence of signs of good functioning machine does not mean that it will always work well, thus, in practice, if the maintenance principles are not met, or the refrigeration equipment is incorrectly used, the device is damaged. Thus, changes in temperature can be caused, pressure discharge or suction, compressor beats, abnormal vibration, etc.

There can be depicted four types of faults [6]:

- Manufacturing faults 10%-(traces of fault at compressor, evaporator, etc);
- Refrigeration faults 20% (e.g. filter logging, less refrigerant than normal.);
- Electrical faults:30 %-(e.g. electric cables are near or on the discharge pipe. Hot surface of discharge pipe can melt

insulation on cables which can cause short-circuit);

- Mechanical faults:40%(e.g. wear pipe rupture, wear and small oil quantity).

Faults displayed in figure 2.

Signs of faulty operation	Causes	Remedial measures
1-The compressor does not work	Thermal relay triggerd	Reboot and control the current intensity
	Discharge pressure too high(dirty condenser)	Eliminate the causes
2-Decrease the capacity of the compresor	Suction valve failure	Verify and replace if is it necessary
	Sucyion filter clogged	Verify and clean filter
3-Irregular discharge of valves	Blocking valves discharge valves for pollution	Checking discharge valve
4-Traices from oil evaporator	Pipe cracked	Pipe repair with welding
5-Discharge pressure is too high	Compresor capacity too large for evaporator	Increases surface evaporator

Fig.2 Refrigeration faults

These defects could have avoided with maintenance, at the defect occurrence it can be fixed with maintenance in the shortest possible time.

4. REFRIGERATION EQUIPMENT MAINTENANCE

Current industry provides expansion, diversification and modernization of industrial equipment, increase of complexity, degree of mechanization and automation of their performance. In the context of this development, increases also the concern for industrialization of maintenance works to rebuild the technical condition of industrial equipment or extend the operation and increase efficiency operation.

Maintaining or restoring the function of a system involves some preventive and corrective actions. All organizational and technical actions necessary to maintain or restore functions are called maintenance.

Corrective actions apply in particular to detect the nature and cause of a fault, the remedy can be made by total or partial replace of one or more elements.

Preventive actions are works of revisions, adjustments, checks and planned repairs. These actions are carried out to avoid catastrophic or parametric defects caused mainly by the wear process. Wear can be classified into: moral wear, chemical, mechanical, corrosion and friction wear.

Maintenance, in accordance with STAS 8174 / 2-77, consists of all the technical and organizational actions related to them, conducted in order to maintain or restore technical equipment (machinery, equipment, device, etc.) to perform the specified function.[5]

Maintenance includes under one name the whole system of technical and organizational maintenance, technical revisions and repair activities that ensure both the maintenance of machinery in running condition and restore it in case of technical failure.

Consequently, maintenance involves two types of maintenance actions, which are used in cooling devices [5]:

- preventive-planned maintenance;
- corrective-unscheduled maintenance.

4.1 Preventive maintenance

Preventive maintenance is the set of all actions performed at predetermined intervals or according to specific criteria, intended to reduce the probability of failure or degradation of equipment operation.

Preventive maintenance is to reduce the probability of failure or degradation of equipment.

Preventive maintenance can be applied at regular intervals to refrigeration components or systems and should be directed to:

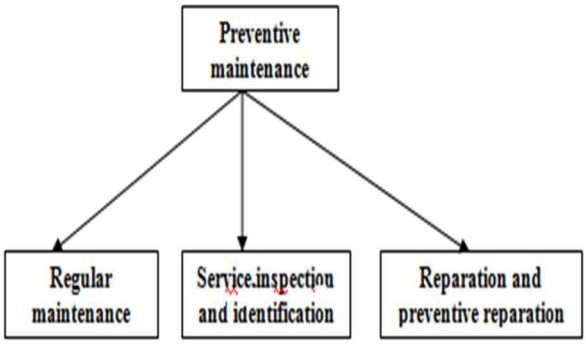

Fig. 3 .Preventive maintenance[5]

- Regular maintenance such as filling oil level, oil change, valve lubrication, cleaning evaporator and radiator, cleaning electrical contacts, measurement of pressure, checkups and other; Maintenance is recommended every 3-6-9-12 months for cooling devices;
- Servicing, inspection, identification, replacement or repair of defective units (Freon leak checks, where appropriate, etc.);
- Replacing parts before they enter into the catastrophic wear phase (changing fan stuck in the cold aggregate, filter change, etc.);
- Develop a prevention program to ensure the efficient operation of equipment and prevent the occurrence of failures.

Preventive maintenance is efficient as:[5]

- reduce-equipment emergency situation at 75%;
- reduce-purchase costs more than 25%;
- increase-maintenance efficiency by 150%;
- increase- life of the equipment by 45%.

Evidence and documentation in preventive maintenance by providing detailed operating parameters is an important process in maintaining the refrigeration system. If parameter record is carried out properly and regularly, then they can serve as a basis for diagnosing future problems. Therefore, it is necessary to:

- perform daily input data;
- perform periodical technical inspections;
- perform service reports.

4.2 Corrective maintenance

Corrective maintenance groups all activities carried out after system failure. These activities consist in detecting the fault, its diagnosis, repair and recommissioning with or without modification (structural) and finally, adjusting the parameters and control the proper functioning of equipment.

Corrective maintenance can be:[5]

- troubleshooting, when reinstatement in function is provisional and is followed shortly by repair;
- repair, when restoring is in agreement with operating conditions.

Corrective maintenance works are difficult to plan as they present a random character both in terms of fault event occurrence and the effect of such a situation. In many cases, when a failure occurs the staff responsible for maintenance is found unprepared and this leads to considerable expense to resolve this situation.

To avoid consequences it is recommended:

- analysis of the failure;
- install safety elements that prevent failure;
- use more reliable technologies;
- establish surveillance methods more appropriate;

Steps of corrective maintenance carried out following a fault for cooling devices are shown in figure 4.

Steps to solve defects during corrective maintenance		**Example**-The compressor at the refrigeration equipment is out of order due to leakage of Freon
Establish the defect	→	Defect engine,blown fuses,it does not freeze
Confirm the defect	→	Measure the compressor,confirm fuse blown
Assess defect	→	Defect engine,because it ran without refrigerant
Causes	→	Due to lack of Freon,wich led to engine overheat(blown fuse)
Determine solution	→	Engine has to be changed,the pipe where was leakage of Freon has to be repaid
Implement the solution	→	Replaced engine,repaired pipe,one day left under pressure

Fig.4 Steps in solving a defect

4.3 Spare parts warehouse

In terms of technical and economic standpoint, spare parts warehouses are needed in performing maintenance. Without spare parts, maintenance cannot be performed and the equipment cannot be repaired in the shortest time. Deposits of spare parts must be organized so that the stock of parts and supplies that will be used for repairs should be:[6]

- First of appropriate quality to meet the needs of all work through preventive or corrective maintenance, so the job can be fully executed;
- Second to be in the right amount (neither less nor more).

The most used consumables and spare parts in refrigeration are:

- filters, valves, compressors, refrigerants, thermostats, oil, thermostatic control valve, etc.

5. EQUIPMENT RELIABILITY

Reliability is based on statistics and probability calculation of events that occur over the life of equipment. Maintenance occurs at different stages of the life cycle of protection system. Between these concepts there are a number of links.

If corrective maintenance allows to bring the equipment to its original condition and if this means to completely replace it, the reliability function is low R0 (t) at the end of each corrective maintenance operation and the average time for good operation (MTBF) is constant and equal to m_0[6].

Average of good operating time - MTBF - is defined as the average time of good operation between two successive failures of a repairable system.

When preventive maintenance operations are carried out at small intervals in relation to m_0, failure of system components or having some of them repaired, damage to equipment as a whole is avoided. Reliability function in this case is $R(t)$.

When the period between maintenance operations is constant, the value Δ of MTBF, thus, the average time between equipment failure (corrective maintenance operations) is also constant. Value of m depends of Δ (interval m, $f = \frac{1}{m}$ is the average frequency of equipment failure and can be used as a reliable feature).

5.1 Reliability function R(t)

Probability that an equipment is not detected before the first operation of preventive maintenance in time t_1, is $R_0(t)$.

In the event preventive maintenance enables to know the status of each element in redundancy and repair those that are damaged and if the degree of fault of each component is constant (no degradation process), the conditional reliability of the equipment from time t_1 is:

$$P_1(t - t_1) = R_0(t - t_1) \quad (1)$$

Overall, to all maintenance operations having, cu $t_0 = 0$, then:

$$R_i(t) = R_i(t_1).P_i(t - t_i) \quad (2)$$

where: $$P_i(t - t_i) = R_0(t - t_i) \quad (3)$$

then:

$$R_i(t) = R_0(t_1).R_0(t_2 - t_1)....R_0(t_i - t_{i-1}).R_0(t - t_i) \quad (4)$$

In the event, preventive maintenance operations are carried out at regular periods Δ, from $t = 0$, $t_i = i\Delta$, relation (4) becomes:

$$R_i(t) = [R_0(\Delta)]^i.R_0(t - i\Delta) \quad (5)$$

In the event preventive maintenance does not allow repair but of a certain element which are faulty, relation (3) is not valid.

Moreover, conditional reliability $P_i(t - t_i)$ is different according to possible status (j) of elements at the end of the preventive maintenance operation carried out in t_i, thus, relation (2) is:

$$R_i(t) = \sum_j R_{i,j}(t_i).P_{i,j}(t - t_i) \quad (6)$$

In conclusion we can say, reliability function it's a very important part for both maintenance (preventive and corrective).

6. FINAL CONCLUSIONS

We have come to the conclusion that:
Maintenance, namely preventive maintenance is important for a good functioning of the refrigeration equipment as:

- spare parts faulty is reduced;
- operating efficiency is increased;
- reduces the time of stagnation;
- increase the life of the refrigeration equipment;
- repair costs are reduced;
- improves the duration of use.

Through maintenance on refrigeration is reduced the environmental pollution with CFC or HCFC refrigerants.

Maintenance activity has to be seen as an investment in the future. Maintenance helps refrigeration equipment to reduce wear.

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STUDII ŞI CERCETĂRI PRIVIND MENTENANŢA ECHIPAMENTELOR DE PRODUS FRIG.

Rezumat: Studiile bibliografice făcute pentru mentenanţa echipamentelor frigorifice au un rol important atăt industrial şi căt şi uz casnic. Echipamentele frigorice după un anumit număr de ore de funcţionare,numai au aceaşi indici de exploatare,starea lor tehnică înrăutăţindu-se datorită unor cauze multiple.Apare astfel necesitatea efectuării unor intervenţii de mentenanţă(corectivă sau preventivă),prin care echipamentele să fie repuse în stare de funcţionare pe perioadă de timp bine determinată.Prin mentenanţă se reduce stagnarea echipamentelor şi se reduce fenomenul poluării cu freoni.Scopul lucrări este studierea şi cunoaşterea mai aprofundată a tipurilor de mentenanţă utilizată în frigotehnie,impreună cu cele fiabile,pentru a prelungi durata de funcţionare a echipamentului frig sau creştea eficienţei de exploatare acestora.

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