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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

UNIDO

TEHNOFRIG S.A.

PHASING –OUT ODSs at TEHNOFRIG S.A.

Project No. MP/ROM/96/136

Contract No. 97/150

FINAL REPORT

June 1998

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SUMMARY

This report summarises the implementation of the UNIDO supported project to phase-out the use of ozone depleting substance (ODS) at the Tehnofrig company in Cluj-Napoca in Romania. The report is compiled according the the paragraph 2.22 g) of the contract: "A Final report in ten (10(copies covering the work performed at the Plant Site (and abroad, if any), before 31 December 1998."

The contract between UNIDO and Trans-Mond Environment Ltd. was signed on 16.09.1997/24.9.1997.

The contractor's team paid three visits to the plant site in Cluj-Napoca as follows:

- October 1997 to get familiar with the site conditions and the counterpart's situation, and to compile a work programme jontly with the counterpart.
- April 1998 to install, commission and test the equipment
- May 1998 to train the counterpart's staff and to facilitate the mass production.

The tasks performed by the counterpart (redesign, testing, field tests) were reviewed and information communicated between the contractor and counterpart. The contractor delivered the counterpart some data and information on some supplies, test procedures etc. to facilitate the production.

The equipment, charging stations and leak detectors were procured at the beginning of 1998 and delivered to the counterpart's site in March 1998.

The steps mentioned above are described in more details in progress reports and purchase reports delivered to UNIDO earlier.

The training, implemented at the end of May 1998 as well as the issues related to the facilitation of the mass production are described in more details in this report. Based on the last visit and discussions with the counterpart the contractor has compiled a list of recommendations which the counterpart may take into consideration and seek some additional funding for their implementation.

At this stage the counterpart will be able to produce commercial refrigeration equipment, without ozone depleting refrigerants, according to the market and demand situation in Romania. The totally changed market situation in Romania means that the future production will be, more or less, in batches and Tehnofrig S.A. needs to continue the development work responding the market needs.

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1. Description of the Project Implementation

The following table, as per the terms of reference of the project, summarises the implementation of the different tasks:

Task/Activity	
1. Visit to the Counterpart	The contractor visited the counterpart in October 1997, collected background information and surveyed the site
2. Work plan	Compiled in Oct-Nov 1997 jointly with the counterpart
3. Redesign of the first model	Done by the counterpart, reviewed by the contractor Sep 1997-Feb 1998
4. Prototype testing	Done by the counterpart, reviewed by the contractor
5. Field test and response	Done by the counterpart, reviewed by the contractor
6. Redesign of the remaining models	Done by the counterpart, reviewed by the contractor, Jan – Apr 1998
7. Purchase of the equipment	Procured and delivered to the site in Dec 1997 – Mar 1998
8. Installation, commissioning	Installed and commissioned in April 1998
9. Starting mass production, on the job training	Discussion on facilitation mass production, suggestions on improved work methods, equipment, training of counterpart's staff May 1998

2. Equipment

The equipment delivered and installed was as follows:

*automatic charging board for mass production, Robinair
*evacuation and charging board for service, Robinair
*two leak detectors, models CPS L-780a and L-790.

It may be noted that the equipment specified and procured may not be the best possible solution in the changed market and production situation in which the production is most likely needed to be arranged in batches. Clients usually want the equipment quickly delivered which is also a condition for Tehnofrig S.A. to stay in the market.

The theoretical vacuuming capacity of the equipment (which has a combined vacuuming and charging function) delivered is certainly enough e.g. for a period of a quarter of the year, but in batch wise production the whole capacity of the equipment is needed for vacuuming thus preventing the operation of the charging function when vacuuming is being done. It would therefore be good, when the production is increasing, to arrange the vacuuming using separate vacuum pumps (which are relatively inexpensive) an reserve the capacity of the equipment procured for charging only, and for possible after sales warranty operations.

Annex 1 of this report discusses some improvements on the equipment, which improvements would be rather easy and inexpensive to implement.

3. Training

The initial ad hoc training was organised in the connection of the equipment installation and commissioning in April, 1998 when the equipment was tested at the counterpart's site.

The actual training was organised in 27-29 May, 1998. All the contractors technical staff (foremen and technical designers, 12 people) attended the lectures and hands-on demonstrations. The training consisted of for theoretical/technical lessons, followed by discussions, as follows:

- Why new refrigerants?
- Properties of new refrigerants
- Lubricants with the new refrigerants and their proper handling
- Unit dehydration and the vacuum process

The practical training and demonstrations at the plant site/workshop covered the following issues:

- Charging the unit with refrigerant
- Detection of the leaks

The training material/guidelines used are attached in this report.

The contractor understands that all the technical staff and foremen of Tehnofrig S.A. have a very good technical and theoretical background and have thus been able to fully adopt the issues related to the new refrigerant and their handling. It is expected that this professionalism will reflect in the future craftsmanship of the production and maintenance regarding the refrigerant component.

Summary of the training material is attached, annex 2.

4. Enhancement of the mass production

Tehnofrig S.A. is operating in conditions which are very different from its past. The production volumes are dictated by the market and the company's capability of marketing. There is a tough competition from foreign suppliers of commercial equipment. The local demand is obviously picking-up when the new retail sale structure, with regional and even nation wide chains, branded articles etc. This means a larger commercial cooling, refrigeration and freezing capacity, but also more technical requirements for the equipment and its producers and maintenance operators like Tehnofrig S.A.

The equipment producer is needed to respond quickly to the demand, produce short series and modify the technical properties of the equipment according to the customers' needs, use most likely several alternative components and e.g. equipment's outer designs. This all means that the mass production, as it used to be earlier, has changed its nature and in practice means the quick manufacturing of short series. To cope all this is a necessity for the company to stay in the market.

Annex 3 of this report discussed in more detail one important aspect of the production technology; how to arrange an effective vacuuming to respond to fluctuating demand and batch wise production requirements

5. Conclusions and recommendations

The project implementation went smoothly. The counterpart seems to be very willing to adopt the technology and technical solutions used by new competitors. The current production facilities and their arrangement might be a limiting factor in facilitating the production in an optimum way and the company may need to invest some funds to straighten some bottlenecks.

Regarding the refrigerant conversion the company and its staff are well prepared. The responsible people have procured commercial information on equipment and non-ODS substances available. The technical staff, foremen and designers are very well trained in the basics and it is obvious that the training arranged within this project is well received and adapted in the practical production and technical solutions.

The changing market of the commercial equipment is presenting the biggest challenge to Tehnofrig S.A. It is clear that the demand for commercial refrigeration equipment will be booming within few coming years in Romania. Tehnofrig may not be able to compete with larger foreign suppliers but must rely on the vicinity of the domestic clients, its ability to produce equipment designs according to clients' needs and tailor solutions. This also means that the future production of commercial equipment is hardly "mass production", but may reach some 4000-5000 units p.a. at maximum. The most important issue is to keep the product quality at a level which corresponds the price and be prepared for short through-put times, i.e. batch wise production to satisfy the clients' needs.

For this batch wise production the equipment specified in this project may not be the most feasible one. The vacuuming capacity presents a bottleneck. The vacuuming, i.e. dehydration of units to be charged takes a very long time and thus prevents the combined equipment from being used for charging.
It is therefore recommended that the vacuuming will be arranged using separate vacuum pumps or their combination (vacuum station) and charge the equipment with separate charging machine.

ANNEX 1

DETAILS OF THE REFRIGERATION UNIT EQUIPMENT

1. The suction line heat exchangers

The suction line heat exchangers are used to sub-cool the liquid refrigerant which will cause a temperature rise of the suction vapour. Sub-cooling the liquid refrigerant is the simplest and most effective way to improve the system cooling capacity. This means however that there must be an external heat sink. If the heat is lead to the suction gas causing a temperature rise, the vapour volume increases. This, in turn, means a smaller mass flow through the compressor due to a smaller vapour density. It depends mainly on the latent heat of vaporisation (L) whether the process gives some extra cooling capacity or not. One can say that if L has a large value, the process ought not to be taken into use. For refrigerants like R 134a there is an increase of the cooling capacity up to 2..4 %.

The suction line heat exchanger has some advantages as well as disadvantages.

The main advantages are:

- an improved oil return from evaporator due to lower oil viscosity;
- no flash gas exists in the liquid line which means a better function of the expansion valve;
- thermal insulation of the suction pipe is not necessary; and
- a reasonable superheating of the suction vapour improves the compressor capacity (less danger of liquid slugs).

The main disadvantage especially for hermetic and semi-hermetic compressors
is that the compressor motor windings are working at a higher temperature. Also the discharge temperature of the refrigerant vapour is higher, which can cause a decomposition of the lubricant, if the pressure ratio of the compressor is high.

2. Suction line liquid accumulators

Suction line liquid accumulators are recommended in cases of flooded or "wet" evaporators. Their main task is to protect the reciprocating (piston) compressor to suction liquid refrigerant, as this will damage the compressor valves within a great probability.

Units using a capillary tube as a throttling device the suction line liquid accumulators replace the liquid receiver. Because there always is a pressure equalisation after the compressor has been switched off by the thermostat, it is necessary that the unit has enough extra volume in its low pressure side. In such cases the suction line accumulator is necessary.

3. Oil separators

The efficiency of oil separators for small units seldom exceeds the value of 96 % which means that from the oil leaving the compressor when the unit is running, 96 % is returned directly from the oil separator to the crank-case of the compressor, the rest of the oil returning back to the unit via the condenser and evaporator through the suction pipeline.

Because the oil surface tension and viscosity will increase when there is a drop of temperature, it also means that the oil droplet size grows up when the temperature sinks. This means that the oil separator efficiency increases with a sinking temperature.

The most effective oil separators are based on the centrifugal process or using different metal filters. Oil separators are recommended for open or semi-hermetic type compressors if the evaporating temperatures are below zero degree (Celsius).

ANNEX 2

United Nations Industrial Development Organization

UNIDO

TEHNOFRIG S.A.

Project No. MP/ROM/96/136
Contract No. 97/150

Phasing-out ODSs at Tehnofrig S.A. Cluj-Napoca, Romania

TRAINING

May, 1998

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The training programme which follows is a summary and an outline of a two training exercises to familiarise the technicians and operators to handle non-ODS refrigerants, mainly HFC 134a. The programme covers both the background issues & theoretical aspects as well as the most common practical issues and questions when the refrigerant is actually charged into a new equipment or an old equipment is retrofitted to use R 134a instead of R 12 e.g.

The programme can be easily implemented in two sessions, the first one covering the background, the second one the practical aspects and some hands-on exercises. For the latter a workbench, basic tools and refrigeration equipment is needed.

The training session will be arranged in two parts

1st session/day: Theoretical issues

Item	Subject	Duration
0.	Opening of the training session	10 min
1.	Why new refrigerants? discussion	30 min 10 min
2.	Properties of new refrigerants discussion	30 min 10 min
3.	Lubricants with the new refrigerants and their proper handling discussion	30 min 10 min
4.	Unit dehydration and the vacuum process discussion	30 min 10 min

2nd session/day: Practical training

Item	Subject	Duration
5.	Charging the unit with refrigerant	2 hours
6.	Detection of the leaks	1 hour

The following chapters 1-6 outline the contents of each sub-session mentioned above.

1. WHY NEW REFRIGERANTS?

The first fluid used as a refrigerant during the early years of the refrigeration technology was ethyl ether, which was easy to produce. It was however highly inflammable and therefore it was replaced about 120 or 130 years ago by other fluids, which sometimes are called as "The Classic Refrigerants", namely ammonia, sulphur dioxide, methyl chloride and carbon dioxide.

In the year 1929 a methyl chloride refrigerant leak in the evaporator of an air conditioning central unit of a hospital building caused several death-cases and as a following of this tragedy the scientists of the American Du Pont company reported of the discovery of a new type of refrigerant which was announced to be not harmful for human being. This refrigerant was called as Freon 12. Soon a large quantity substances related to it were taken into use.

"Freon" is a registered Trade Mark for chloro-fluorocarbon refrigerants manufactured by DuPont. Other Trade Marks for the same subjects are for instance Kaltron. Arcton, Forane, Algofrene, Genetron Frigen, Carrene and others. They normally are not harmful for the health if the quantity of the refrigerant in the inhalation air does not exceed 10 %. These refrigerants also have some good properties: most of them do not cause corrosion with the exception of dur-aluminium compounds; they are not inflammable or explosive and they do not spoil foodstuff in case of a refrigerant leak. It seemed that these refrigerants would serve the cooling technology for a long era.

In 1972 two American scientists - Rowlands and Molina - reported in the annual meeting of the U.S.A. National Association for Chemical Engineers about the results of a theoretical study based on a computer program: if the refrigerants containing Chlorine (Cl) were allowed to enter the atmosphere at the rate of 1970, they would cause a decomposition of the Ozone layer in stratosphere.

Stratosphere is a part of the atmosphere surrounding the globe. Its lower boundary is at a height of about 10 km above the earth surface and it slowly diminishes when going upwards. This layer of atmosphere contains principally the same gaseous elements as our normal atmosphere, with only one exception: the contents of Ozone ($O3$) is remarkably higher in the stratosphere than on the sea level. The reason of this is that Ozone is formed in the stratosphere due to the high intensity of the ultraviolet radiation of the Sun.

Ozone $O3$ is an allotropic formula of Oxygen $O2$. It however has some deviating physical and chemical properties when compared with Oxygen. One of the most important properties is its reaction to the ultraviolet solar radiation.

The ultraviolet radiation is an invisible part of the radiation and it has always a shorter wavelength than the visible light. Its penetration ability is higher than that of visible light and it also has a different influence to the tissues of the human being. An overdose of ultraviolet radiation will lead to the burning of the skin and in the long run the fatal result will be melanoma or skin cancer. Ultraviolet radiation also can create mutations in the cells of animal tissues.

Ozone can absorb ultraviolet radiation and thus prevent it from entering into the lower parts of atmosphere, whereas the normal Oxygen allows the ultraviolet radiation to pass without any absorption. Therefore, high Ozone quantity of the stratosphere allows less ultraviolet radiation to enter the lower parts of the atmosphere. If the amount of Ozone gets smaller in stratosphere, a higher intensity of the ultraviolet radiation is to be expected on the sea level.

What do the refrigerants have to do with this problem?

The chloro-fluorocarbon refrigerants have very strong inner binds between the halogen ions and carbon inside the molecule. Therefore their "living length" in the atmosphere is long: from decades to centuries. If these subjects are allowed to enter the atmosphere, they will stay there neutral i.e. without reacting with any other subject for a long time.

In some cases they can, however, enter the stratosphere. This can happen for instance with a hurricane or other climatic storm, when cyclones can occur. Then these halo-carbon molecules also can reach such altitudes where the ultraviolet radiation intensity is high.

The high energy quants of the ultraviolet radiation will hit the halo-carbon molecules and cut the chlorine atom out of the molecule. The free chlorine ion will react with ozone resulting one normal oxygen molecule and one chlorine monoxide molecule. When this chlorine monoxide molecule meets a second ozone molecule, it will react again with two normal oxygen molecules and one free chlorine ion as results. This double reaction can be repeated up to one hundred thousand times. The destruction of
the ozone molecules will allow more ultraviolet radiation to pass through the atmosphere down to the earth surface which will have fatal consequences for the life on earth. It has been estimated that the amount of lethal skin cancer cases would increase to about 100,000 per annum, if the halo-carbon emissions will remain on the level of 1970´s.

Yet there is another phenomenon to be considered within the chloro-fluorocarbon refrigerant emissions in the atmosphere. Some of the gases existing in the atmosphere can absorb the long wave infrared radiation or heat radiation from earth to space. This will in term diminish the heat losses of the globe to the surrounding space thus causing a temperature rise on earth. This phenomenon is called "the green house effect". The most important gases which are able to absorb this heat radiation are carbon dioxide (CO2) and water vapour (H2O). Many of the halo--carbon refrigerants also can absorb heat radiation and therefore they also have a certain effect on the temperature balance on earth. Many scientists think that the ozone depletion however is far more dangerous for the mankind than the greenhouse effect.

2. PROPERTIES OF NEW REFRIGERANTS

The danger of the ozone depletion in stratosphere gave a signal to the scientists: the refrigerants which can affect the destruction of the ozone layer must be replaced by new, less harmful refrigerants. Because the ozone layer diminishing is caused by the emission of chlorine ions, it was obvious that the new type refrigerants should not contain any chlorine.

There were two ways to find or develop these new fluids: either to use pure chlorine free subjects or their mixtures. The former way has produced such refrigerants as R 134a and R 23, the latter mixtures like R 404a and R 407a. The quantity of these new refrigerants is now roughly 20 but it is growing up.

R 134a was the first chlorine free refrigerant being tested comprehensively. It is nowadays used widely both in refrigeration and air conditioning systems, and the results are good. It has thermodynamic properties which are quite similar to R 12: refrigeration capacity, temperature and pressure levels as well as requirements of running energy are close to the values of R 12. Its ODP-value (ODP = Ozone Depletion Potential) is 0, whereas R 12 has an ODP-value of 0,95. Another factor, GWP (GWP = Global Warming Potential) tells the heating ability of one molecule compared with the heating ability of one carbon dioxide molecule during the period of 100 years.

The toxicity of different refrigerants can be illustrated in many different ways. The toxicity factor given below is based on the American AEL -standard and it gives the maximum allowable contains of the refrigerant of bereathing air in ppms (1 ppm = 1 particle per million = 0,0001%).

The inner construction of the refrigerant R 134a molecule is not symmetric, but three (3) of the four (4) fluorine atoms have a connection with one of the two (2) carbon atoms, whereas the other carbon atom has a connection with only one (1) fluorine atom and two (2) hydrogen atoms. This makes the molecule polar, which means that there is an electrical potential difference between the ends of the molecule. This causes that the miscibility of this subject is poor compared with other refrigerants, for instance R 12. This problem will be discussed later with the lubrication question.

Refrigerant R 134a is neither toxic nor flammable. Its molecule size is however smaller than for instance the R 12 molecule and therefore it can penetrate through the construction materials of the refrigeration unit easier than a R 12 molecule. This means that the leak testing process must be made more carefully than with R 12 units and systems.

All the mixtures (or blends as they also are called) have the same properties in connection with oil as R 134a. When R 134a mainly is considered as an alternative to replace refrigerant R 12, some common blends will replace other refrigerants as follows:

Blend name	Substitute to	ODP (R11 = 1,00)	GWP (CO2 = 1,0)	Toxicity
R 404a	R 502	0,0	3750	1000
R 407a	R 502	0,0	1610	1000
R 407c	R 22	0,0	1890	1000

The new refrigerants and their mixtures are very hygroscopic and more sensitive to moisture than for instance R 12. Therefore, larger capacity filter dryers are necessary than for old refrigerants. The filter drier desiccant also must be matched to the smaller molecule size of R 134a.

The new blends do not have a constant boiling point temperature at a constant pressure but instead of the boiling point they have a boiling area, which means that at a constant pressure the change of state will happen inside a gliding temperature range.

3. LUBRICANTS WITH THE NEW REFRIGERANTS

Lubricants are an essential component of all refrigerant systems. Like all mechanical equipment, also a reciprocating refrigeration compressor bearings and pistons require lubrication. For a screw compressor lubricant also acts as a seal and it transfers a remarkable amount of heat generated by the working of the compressor.

The question of a suitable lubricant for R 134a and its mixtures has been quite a problem. The traditional mineral oils, vegetable oil based lubricants or synthetic oils are not miscible with R 134a or its mixtures and therefore practically seen no oil transmission can occur with this refrigerant. These non-mixable oils have a high surface tension potential in combination with R 134a and therefore there will not be any
thin lubricating oil layer in the bearings. The oil will settle on the surfaces of the heat exchangers such as evaporator and condenser and prevent there effectively the heat transfer which causes the engine stop.

Polyester (POE) and Polyalkylene Glycol (PAG) lubricants are used with the new refrigerants and their blends. POE and PAG lubricants have similar characteristics to the traditional oils but are less hygroscopic, dependent upon the refrigerant solubility. This demands special care during manufacturing and dehydrating as a part of it, transport, storage, and charging of the lubricant. This is necessary in order to avoid chemical reactions in the plant, such as hydrolysis. Especially PAG lubricants are critical in this respect. These lubricants are used mainly in cases where an especially good solubility is required due to a high rate of oil circulation (car air condition). In these systems, no copper alloys are allowed.

A large majority of compressor manufacturers prefer the use of POE lubricants and for this extensive experience already is available. The results are positive, if the water content in the lubricant does not exceed 100 ppm.

4. VACUUM HANDLING OF THE PLANT

The vacuum handling or evacuation of the plant is necessary for three (3) reasons:

- to remove air;
- to remove moisture, and
- to remove all non-condensable gases which can be dissolved in the lubricant charge of the compressor.

The necessary time for the evacuation process depends on the capacity of the vacuum pump, amount of water inside the system, internal volume of the system, pipeline length of the system and presence or absence of lubricant.

The water inside the system can be removed only in gaseous state, i.e. as a vapour. If all the water already is in vaporous state, there is no problem in removing the moisture. If the water inside the system is in liquid stare, it must evaporate before it can be removed. The boiling temperature of water depends on pressure and it becomes lower when the pressure sinks. For an effective moisture removal it is therefore necessary to warm the system with an electric heater or infra-red lamp. If, however, the moisture is dissolved in POE or PAG lubricants, evacuation is not an effective method at moisture removing.

The vacuum pump capacity must be sufficient for the system internal volume. On the other hand, the system inside volume is a function of the system cooling capacity. One can say that normally, a vacuum pump with a suction flow 90 litres/min is suitable for a system having a cooling capacity less than 10 kW.

The vacuum pump connecting hose to the system must have at least an inside diameter not less than 10 mm. The pump must be connected both to the low and high pressure sides of the system. All valves (also solenoid valves) must be open during the evacuation system.

The one stage evacuation system down to a high vacuum of 0,05 to 0,1 Torr or 0,07 to 0,14 mbar is the most effective, but it also takes the longest time.

Triple evacuation is used quite often because it is quick and does not require a special vacuum gauge. By this method, the system is at first evacuated down to 50 Torr or 70 mbar and thereafter the vacuum is broken to atmospheric pressure using the same refrigerant which will be charged into the system. Then the system will be evacuated again down to 70 mbar. Thereafter this process will be repeated. After the third evacuation the system is ready to be charged with refrigerant. This system has two disadvantages: at first it will not remove the liquid water from the system and it causes extra emissions of fluorocarbon refrigerant to the atmosphere.

As a compromise, an one-purge evaporation with the vacuum of 1,5 to 3 mbar also can be used. Using this system, the necessary vacuum suctioning time normally exceeds 2 hours.

5. CHARGING REFRIGERANT R 134a TO AN EXISTING R 12 UNIT

5.1. General Remarks

When an existing refrigeration unit will be recharged with refrigerant 134a the following basic data ought to be recognised:

a) Cooling capacity of the unit
b) Evaporation and condensing temperatures,
c) Type and amount of refrigerant charge, and
d) Type of oil charge inside the system.

The compressor manufacturer ought to be consulted for the potential need to change some of the system components if necessary. It must be noticed that some materials of the unit may not be suitable for use with refrigerant R 134a.

2. Adjusting the unit for R 134a

A complete test for refrigerant leaks of the unit must be done before the unit adjustment for the new refrigerant.

The compressor unit has to be separated from the refrigeration circuit by means of shut-off valves. The existing oil charge will be drained off from the compressor body and crankcase as well as the eventual oil separator and oil tank as complete as possible.

Charge the unit crankcase with polyester oil and discharge the air thoroughly with a vacuum pump down to 0,8...1,0 mbar. Switch on the unit to run with R 12 charge and let the unit run at least for 48 hours to get the previous oil charge thoroughly mixed with the polyester oil. Switch the unit off and remove the oil charge from the compressor crankcase. Check the mineral oil percentage of the oil mixture. The mineral oil quantity shall not exceed 1 % of the total oil mass.

The process described above must be repeated at least two or three times until the amount of the mineral oil is less than 1 %.

The R 12 charge of the unit must be removed from the plant and destroyed according to the official rules and instructions given by the local authorities. The refrigerant charge may also be sent to be purified for recycling.

The oil charge of the compressor crankcase, oil separator and oil tank must be removed as completely as possible.

Change all the dryers, suction gas strainers and other filters of the refrigerant circuit. Replace the old expansion valve with a new one suitable for R 134a, if necessary, and do all the other replacements specified by the compressor unit manufacturer.

Check all the components (solenoid valves, one-way valves etc.) for proper operation and replace if necessary.

Install a new moisture indicator suitable for R 134a to the liquid line.

Make a thorough, complete test for leaks and repair all existing leaks.

Get a vacuum to the unit which is not more than 0,6 mbar (0,3 mbar for the freezing plants). The vacuum must remain below 1,3 mbar at least for three (3) hours. Alternatively, the vacuuming process can be finished with the end value of two (2) mbar, if the process is done twice with a break-the-vacuum operation using R 134a gas.

Charge the plant with R 134a. Note that the amount of R 134a needed is smaller than the previous R 12 charge.

Switch the unit on and check the whole unit for proper operation. Check the system once more for the leaks.

Let the unit run roughly 40 - 50 hours and check the refrigerant circuit humidity using the moisture indicator. If the system is moist, replace the filter drier. Get a sample from the unit oil and check the water contents of the sample. The water quantity must be less than 50 ppm.

When the operation has been carried through, monitor the running of the unit for a period of two weeks to confirm that the unit is running in a proper way.

Polyester oil MOBIL EAL Arctic 22 or equal meet the requirements of many compressor manufacturers. The oil must be handled only in small quantities because of its very high hygroscopic properties. For service and installation the oil should be purchased in small containers or bottles (max. 5 litres) whereby the absorption of the moisture can be avoided.

6. INSTALLATION OF A REFRIGERATION UNIT WITH R 134A CHARGE

The installation practice for R 134a must be far more proper and cleaner than for CFC or HCFC units.

All the soldered pipeline joints must be made using a protective inert gas which prevents the oxidation of the pipeline inner surface.

Processing the vacuum of the plant must be done with a perfect accuracy. The maximum water content of the unit must be less than 10 ppm. The vacuum must reach a value of 0,6 mbar (0,3 mbar for freezing systems) or alternatively the vacuum must be less than 1,3 mbar for at least 3 hours.

The R 134a installations do require its own peculiar vacuum pump equipped with materials suitable for R 134a. This vacuum pump must not be used with other refrigerants containing chlorine, because chlorine causes an increase of the corrosion intensity of the pump interior. In some cases the chlorine also can be solved with the pump oil and can enter the plant when the pump is running.

The refrigerant charging hoses, gauge sets, charging and discharging units for R 134a must not be used with units using mineral oils, because small quantities of oil always remains inside these tools. This improper type of oil will be transferred into the R 134a -unit and with it also some chlorine will enter the unit. The material of service hoses for R 134a is different with the service hoses for CFC- and HCFC - refrigerants.

Refrigerant R 134a is more sensitive for leaks than for instance R 12. This means that R 134a penetrates easier through the materials than CFC- and HCFC-refrigerants. Thus the leak test must be done more carefully than for CFC- and HCFC -refrigerants.

For the pressure test of the system a mixture of air and R 134a can not be used because this mixture can be explosive.

The special leak testing apparatuses for R 134a have been developed. Normal leak detectors for CFC- and HCFC -refrigerants are not enough sensitive for R 134a.

Polyester oil MOBIL EAL Arctic 22 or equal meet the requirements of many compressor manufacturers. The oil must be handled only in small quantities because of its very high hygroscopic properties. For service and installation the oil should be purchased in small containers or bottles (max. 5 litres) whereby the absorption of the moisture can be avoided.

VACUUM STATION - AN IMPROVEMENT OF THE MANUFACTURING PROCESS

For the manufacturing of different refrigerated furniture (Home freezers, domestic refrigerators, commercial display cases, bottle coolers etc) the vacuum handling process is one of the most important details. According to the recommendations of different technical sources, the vacuum processing time for a small refrigeration plant should be at least two hours. If there is some moisture existing inside the system, the time will get increased to several hours after the vacuuming process, it is necessary to have a vacuum test. During
this test one can check the system for leaks and moisture. This test takes as a minimum 30 minutes, if no problems occur. After passing the vacuum test the system is ready to be charged with refrigerant. This in turn will last from 10 to 15 minutes. When we count for the connecting and disconnecting work as well as for moving the charging unit to the next subject to be handled, we can estimate, that the required time for vacuuming and charging of one unit will last as a minimum 3 hours. From this 3 hours the charging unit is in effective use only 15 minutes as explained above.

This also means that during a working period from 7.00 a.m. to 4.00 p.m. only three units can be handled by one filling station as a maximum.
A monthly production of 300 units means a daily production of 15 units, because there are approximately 20 working days per month. If there is some excess moisture inside any plant or if the system is moist, the amount of units to be handled decreases rapidly.

It is recommended that a separate vacuum handling station be installed close to the charging point of the assembly line for simultaneous handling of several refrigeration systems. Then the station can handle up to five units at the same time.

The vacuum handling station consists of two or more large capacity vacuum pumps connected to a common suction manifold. The separate refrigeration units to be vacumized are connected to this manifold which is equipped with a separate shut-off valve for each branch.

Each unit to be handled has a vacuum handling and controlling list where the time for starting and ending the vacuum process can be written.When the vacuum indicator of the manifold branch indicates an acceptable value for the vacuum, the vacuum test can be done for each furniture separately.

It is also necessary that the connecting pipe between the unit to be sucted town to a deep vacuum should have an inside diameter not too small and the pipe also shall be as short as possible. For instance, a suction pipe diameter of 1/4" means eight (8) times longer suctioning time than in a case where the diameter is 1/2", and a suction pipe length of 2 meters means that the suctioning time will be double compared to a system having a pipe length of 1 meter only, see e.g. Du Pont Refrigerant Service Manual, chapter 6.3.6, page 28.

The charging stations with their own vacuum pumps are used to charge the systems having been vacuum handled.