Part 1:

Best Practice Guidelines for the Usage of R134a as Test Gas

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2 Introduction

This report is the result of an ICAAMC working group on the usage and substitution of R134a as a test gas for turbo compressors. The entire report is divided into two separate parts.

This "**Part 1: Best Practice Guidelines**" documents the experience of the member companies to use R134a. The main focus is the minimisation of leakage or release of test gas to the atmosphere.

"**Part 2: Substitution of R134a**" summarises the attempts of the working group to find a substitute for R134a as test gas. These results are documented in a separate report.

This work has been done in the years 2010 and 2011 by the following companies:

- Elliot Turbo
- Siemens
- GE Infra
- Dresser-Rand
- MAN Diesel & Turbo
- Atlas Copco

3 Minimisation of leakage to atmosphere, example of one major compressor supplier

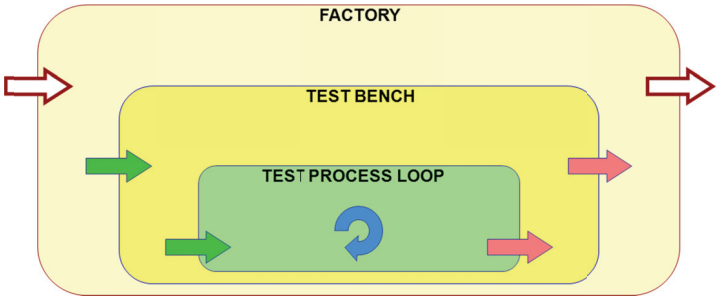
3.1 R134a utilization for centrifugal compressor testing, procedures and management of the gas

- R134a is well integrated in our waste management with administrative and regulatory tracking (traceability).
- Since 2006, the complete recovery or reclamation of R134a is a major objective.
- The gas supply and test operation done by an internal compressor specialist with R134a experience.
- Test operation is done with limited leakages from test process loop and compressor seals.
- The gas recovery / reclamation is done by specialists of R134a with all agreements.
- If feasible, other gases to be used even with more complex sequences and conditions.

3.2 Management of R134a

Main use steps are :

- **Gas filling (& vacuuming)**
- **Test Operation**
- **Gas recovering**



To be in line with legal constraints:

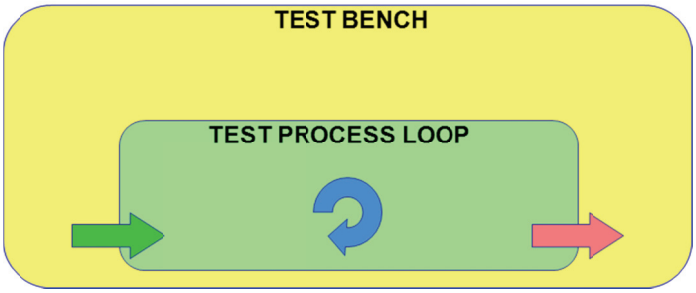
- Waste manifest form to complete from arrival to departure of gas containers. Reference: CERFA Form N° 12571-01 (2005).
- Gas containers installation is done by well trained internal employees.
- Gas recovery and shipping is done by refrigerant specialists with all agreements.

Safety level equivalent to other tests with heavy gases (low level ventilation, liquefaction control …).

3.3 Best practice and procedures

Main use steps are :

- **Gas filling (& vacuuming)**
- **Test Operation**
- **Gas recovering**

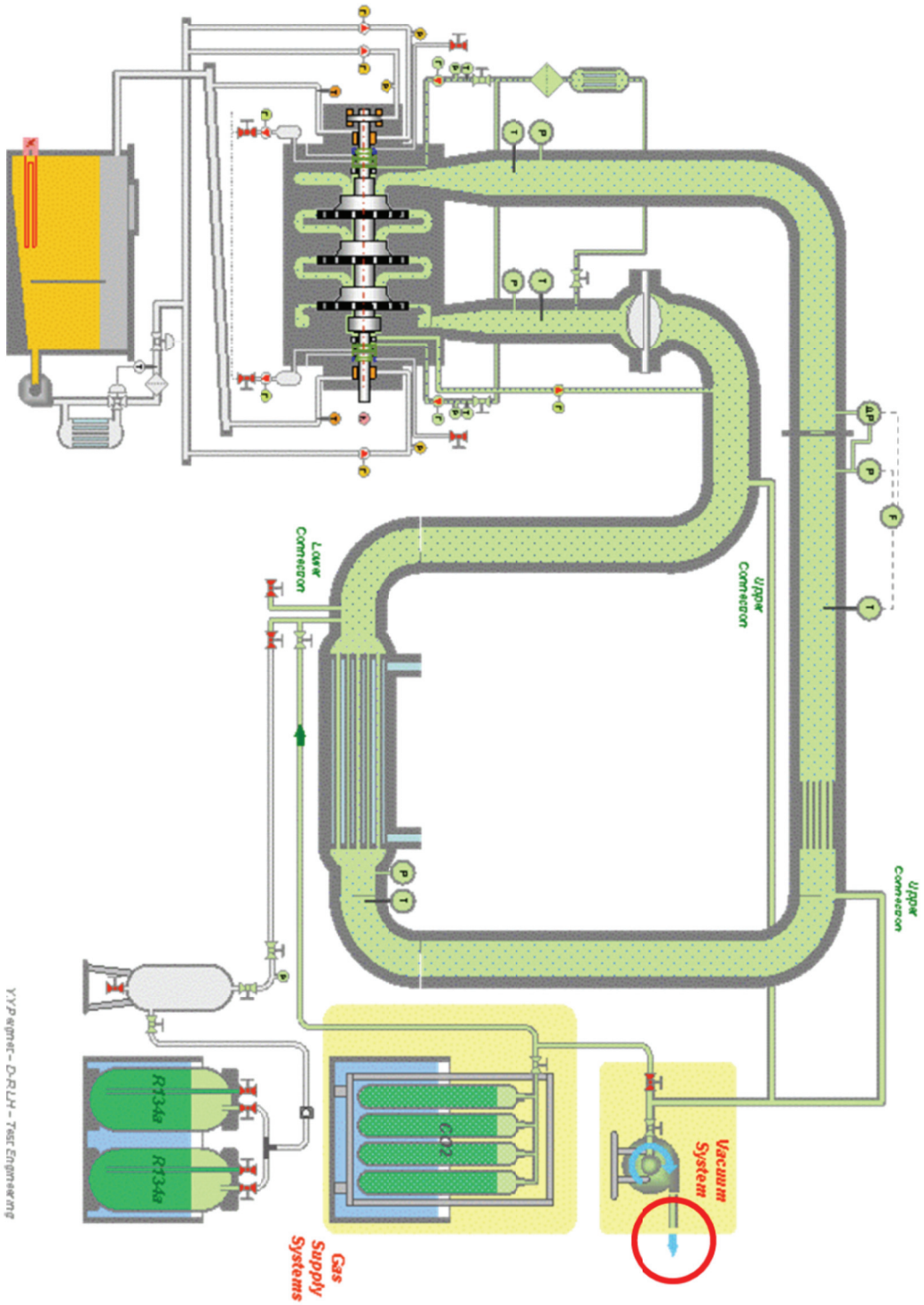


In the process of using R134a, the main objective is:

AVOID LOOSING MOLECULES TO ATMOSPHERE.

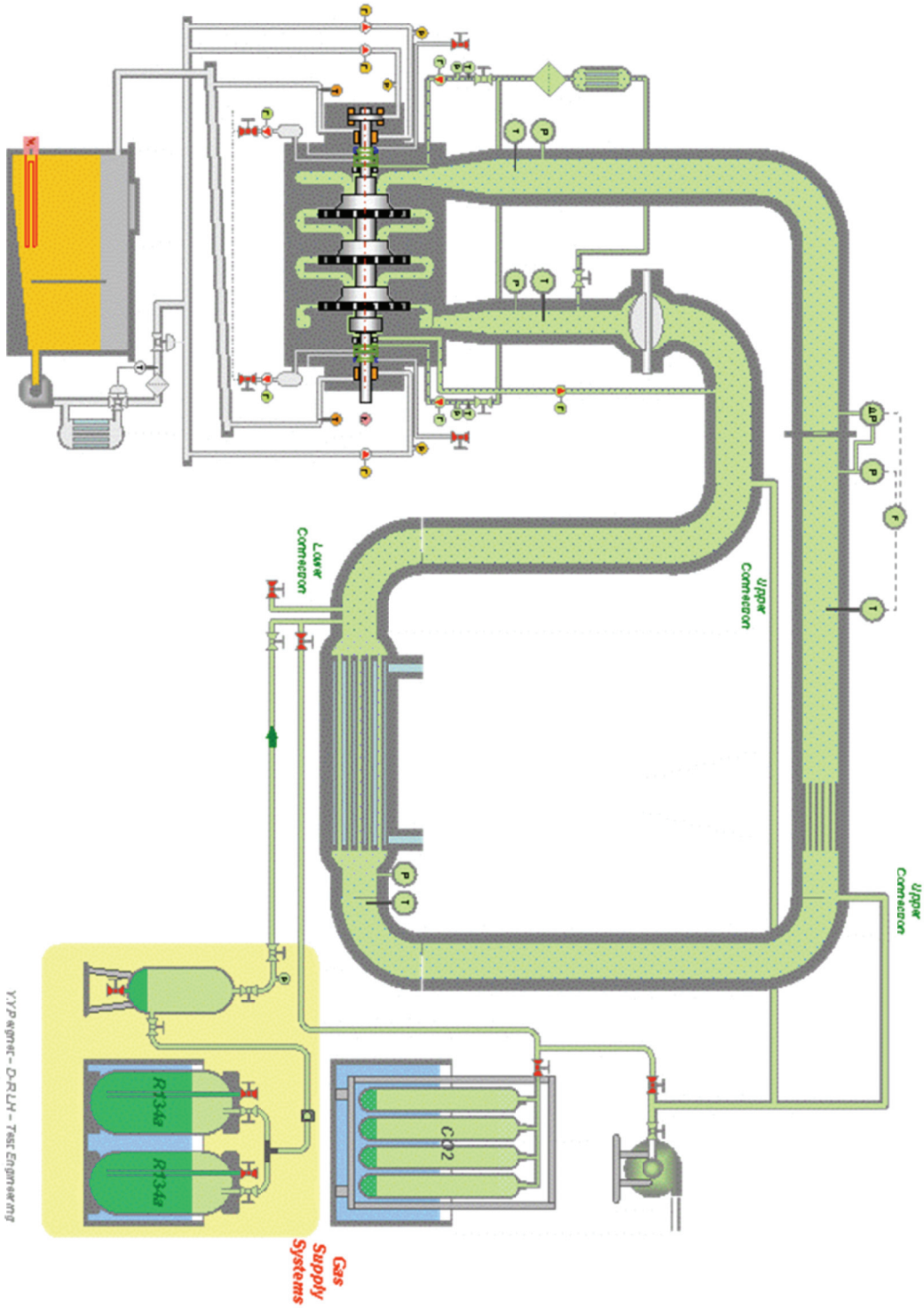
3.4 Gas filling (air vacuuming)

Possible leaks: If R134a supply while vacuuming, leakages at vacuum pump.



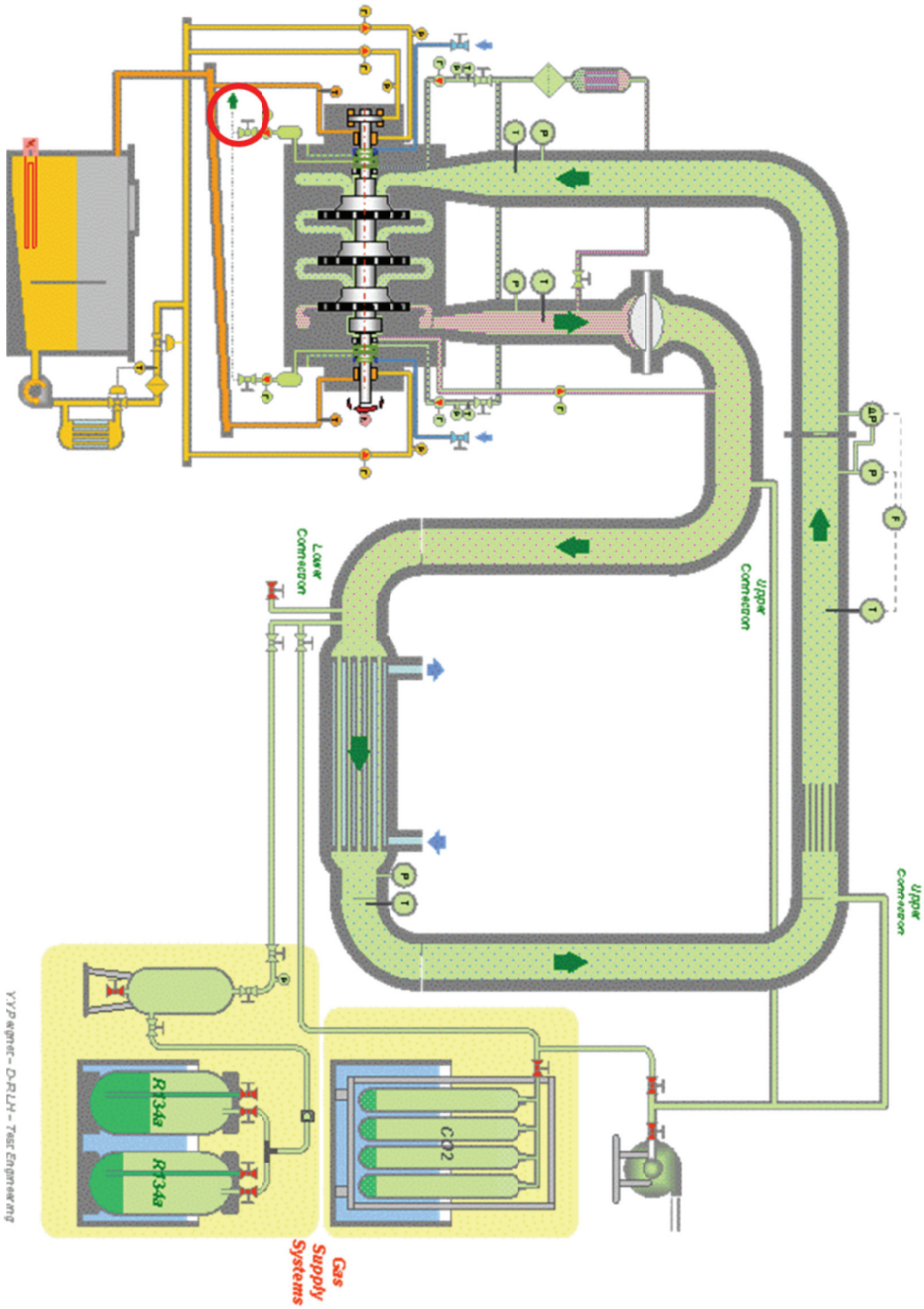
3.5 Gas filling (over atmosphere)

Possible leaks: Very small amount at seals and from process loop.



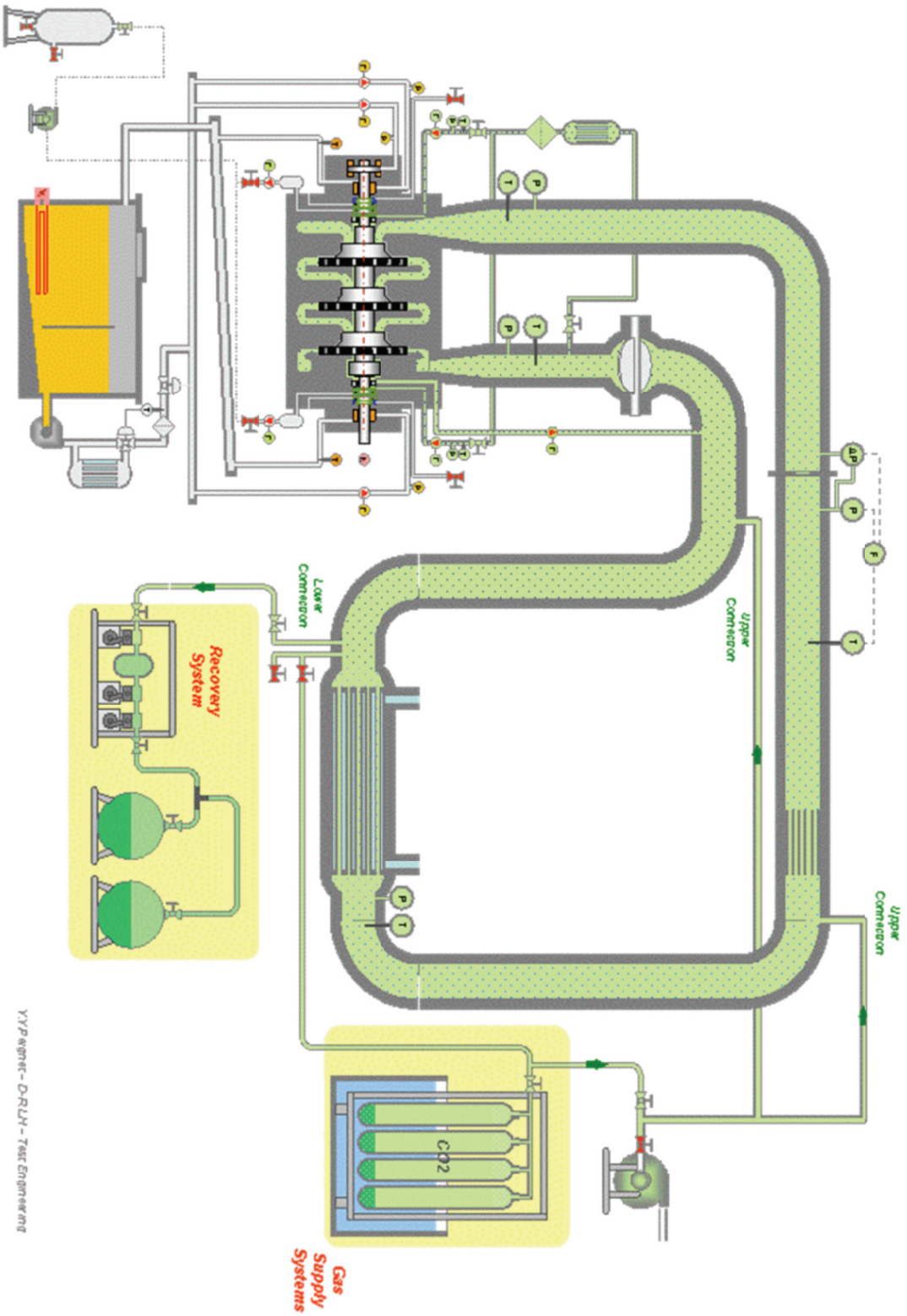
3.6 Test operation

Possible leaks: Leakages at compressor seals.



3.7 Gas recovering

Possible leaks: At the end of recovery, residual pressure of test gas to be flushed.



3.8 Notes

- «Recovery» is the collection and storage of refrigerants from products, equipment or containers during their maintenance or servicing, or prior to their disposal.
- «Recycling» is the reuse of a recovered refrigerant after a basic cleaning operation.
- «Reclamation» is the re-processing of a recovered refrigerant (a controlled substance) to meet the same performance specifications as a virgin substance, taking into account the use for which it is intended.
- R134a is generally recovered and sent to destruction after low power testing (up to 3 tons).
- For similarity performance testing, a mixture of CO_2 + R134a is preferred to pure R134a.
- For large amounts of R134a to be used (more than 3tons), for full load testing generally, a special reclamation system has to be used.

4 Reclamation and recovery of gas after testing

4.1 General plant description

The problem of gas recovery can be solved by a closed loop and a dedicated auxiliary system collecting the gas loop and creating vacuum in the test plant loop in order to recover as much as possible of gas once the test is completed.

A schema of the overall plant is reported in Figure 1.

The recovery system plant consists of a dedicated screw compressor that creates the vacuum (around 0.5 bar absolute) and re-injects the sequestrated flow in a dedicated tank.

However, a small leakage flow rate from primary vent seal gas of the centrifugal compressor under testing is still present and it cannot be recovered due to dry gas seal operating mode requiring a minimum buffer gas pressure. The amount released to atmosphere is quantifiable in around 0.5% of the loop mass.

The stored test gas in the tank can be further treated by a dedicated chiller plant aiming at liquefying the R134a and releasing the lighter gas to the atmosphere (see Figure 2).

This chiller plant works fine in case of a gas mixture made by two or more asymmetric groups of components in terms of dew point (e.g. R134a / natural gas or R134a / N_2).

This cryogenic trap has an economic advantage in case of big machine where for each test, tons of gas are necessary.

In case of similar components in terms of dew point (e.g. R134A / CO_2), we usually reduce the cooling temperature: The resulted biphasic mixture at the imposed pressure and temperature can be treated with dedicated resin to sequestrate R134A and at least a part of CO_2 can be released to atmosphere.

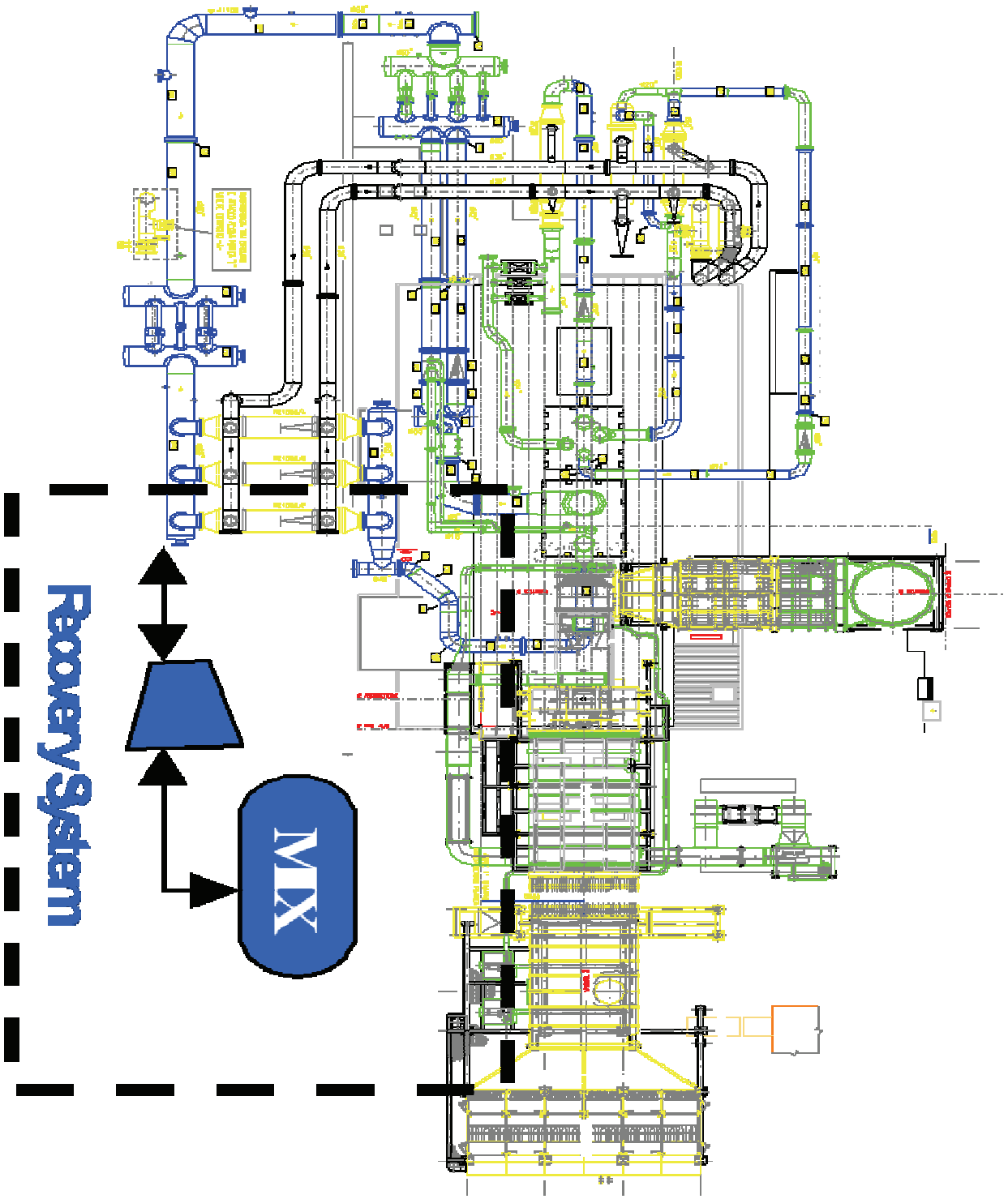


Figure 1: Recovery plant schema

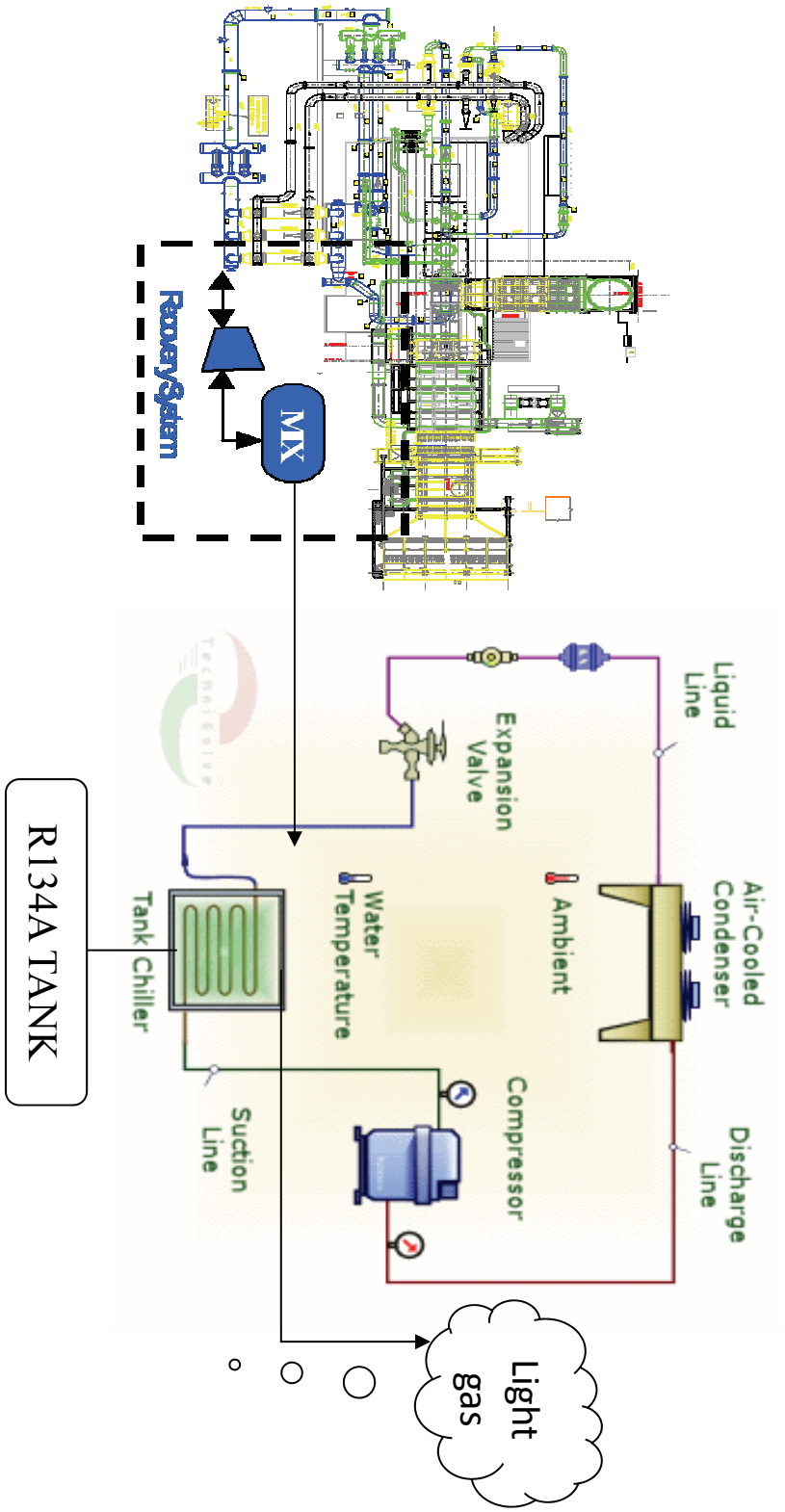


Figure 2: Cryogenic trap schema

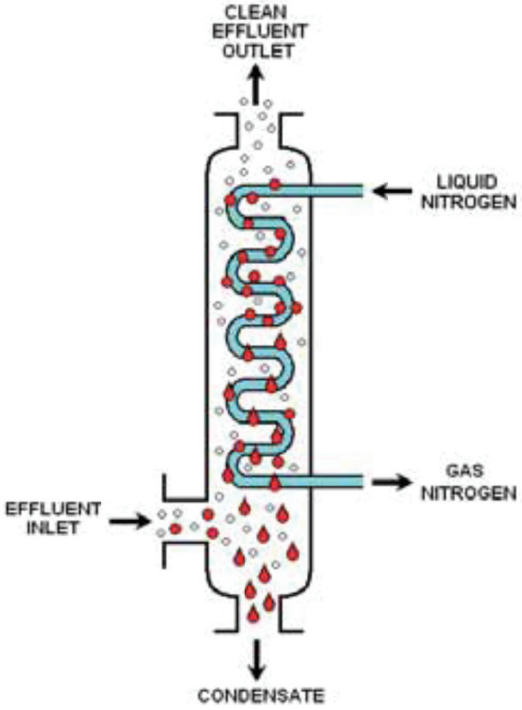


Figure 3: Cryogenic condenser schema

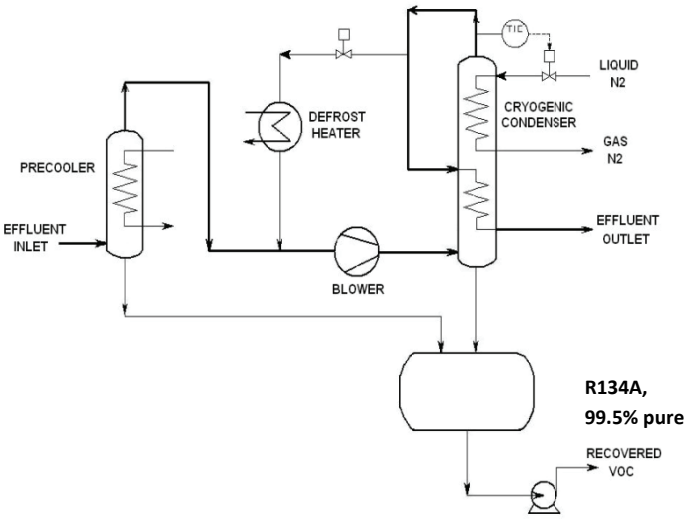


Figure 4: Condenser schema

Figure 5: Cryogenic trap plant

4.2 Recovery plant analysis

Here below is reported a synthetic table of the main quantity of gas used for the testing of an LNG compressor train tested under similarity conditions.

main information	**unit**	**value**
Average impeller external diameter	mm	1500
Expected absorbed power	kW	60,000
Guarantee point gas molecular weight	g/mole	44
Similitude mixture molecular weight	g/mole	60
Gas loop volume	m^3	600
Leakage without any recovery system	%	100% (the entire test gas sooner or later is released to atmosphere)
Leakage with recovery system	%	from 10-20% of total mass
Leakage with recovery system and cryogenic trap	%	from 10-20% of total mass but it allows to recover and stock R134a 99.5% pure that can be reused
Other information related to recovery plant		
Recovery plant dimension	length x width (m)	6 x 2
Screw compressor absorbed power	kW	≈ 300
Recovery plant cost	k$	450
Other information related to cryogenic trap		
Cryogenic plant dimension (including cooler)	length x width x height (m)	3 x 3 x 10
Cryogenic Plant cost	k$	250
Additional cost for R134a separation from CO_2	k$	100