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INCREASED USAGE OF ENVIRONMENTALLY SUSTAINABLE REFRIGERANTS AT VALMET AUTOMOTIVE

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ABSTRACT

The thesis was written to present an AC-filling machine renewal project in automotive industry. It is based on a project the author managed at Valmet Automotive manufacturing engineering department.
During the project, an older filling machine was relocated from the assembly rework station to the production main line, and the rework station received a new filling machine. The subject was chosen, because it involved the author's studies in environmental engineering and because it was a part of his everyday work. As a result of the project, the production department could handle the increased volume of vehicles requiring refrigerant R-1234yf filling.
In this thesis, following subjects are presented: Valmet Automotive as a company and their products, theory of refrigeration process in general, as applied in automotive industry and refrigerants used in the industry. Thesis also covers the actual project and its different phases.

CONTENTS

1 INTRODUCTION

The thesis is based on one of the projects I have worked on at Valmet Automotive. In this project a new AC refrigerant filling machine was delivered, assembled and commissioned in the General Assembly department of Valmet Automotive car manufacturing plant in Uusikaupunki.

Valmet Automotive has enjoyed a great deal of attention nation-wide during the last couple of years due to their rapid growth in business, manufacturing rates, and number of people hired. Their manufacturing deal with Daimler AG for the Mercedes-Benz GLC SUV created around 2000 new jobs in 2017 in the small coastal city of Uusikaupunki in Southwest Finland. Local available workforce was nowhere near large enough, so Valmet Automotive started a recruiting campaign spanning all over Finland.

Following the successful production start of the GLC, Valmet Automotive began manufacturing the fourth generation of Mercedes-Benz A class compact series vehicle in the early 2018. Due to the popularity of this model in the markets which adhere to the stricter environmental legislations, the share of produced vehicles which require the environmentally friendlier AC refrigerant R-1234yf increases. This increased usage of R-1234yf in production leads to the subject of my thesis - the procurement and commissioning of a new HFO-filling machine.

In this thesis I will introduce Valmet Automotive as a company, their roots, and where they are aiming in the future. I will also write about thermodynamical basics behind refrigeration process, refrigeration process in vehicular application, and refrigerants used in the automotive industry.
The focus of my thesis will however be in the project I oversaw and its different stages.

2 VOCABULARY

AC – Air Conditioning.

Baumuster – Option list for vehicle parts and codes.

Daimler AG – A German automotive corporation. Owner of brands such as Mercedes-Benz, Mercedes-AMG, Maybach and Smart.

EV – Electric Vehicle.
A vehicle using an electric motor instead of an internal combustion engine.

Filling machine fills vehicles with technical fluids, such as the brake fluids, refrigerants, coolants, gearbox oil, etc.

GWP – Global Warming Potential.
Value of heat absorbed by a greenhouse gas in atmosphere in relation to CO_2. CO_2's GWP is 1.

HMI - Human Machine Interface.
A display where machine settings can be controlled.

Hunter – Valmet Automotive's Production Management Software.
Keeps information about individual vehicles identities, options and communicates with automated production systems.

ME – Manufacturing Engineering.
Technical department responsible for the planning, development, acquisition and implementation of production machinery.

OEM – Original Equipment Manufacturer.
A company that produces equipment, machinery or parts for another company. For example, Valmet Automotive producing Mercedes-Benz vehicles for Daimler.

PLC – Programmable Logic Controller.
Program code and hardware used in automation systems.

Refrigerant is a substance used in air conditioning, cooling and refrigeration processes.

SUV – Sports Utility Vehicle.
Combines features from off-road vehicles to passenger cars, such as raised ground clearance. For example, Mercedes-Benz GLC is an SUV.

VA – Abbreviation for Valmet Automotive.

3 COMPANY INFORMATION

3.1 History

In 2018 Valmet Automotive celebrated its 50th year in the industry. Founded in 1968, the company today is one of the leading automotive contract manufacturers in the world, and has expanded its business to cover design and engineering services, convertible roof systems, vehicle battery manufacturing, and future mobility solutions. (Valmet Automotive Oy, 2020)

On 15.8.1968 Valmet and Saab made a deal on founding a car manufacturing plant, and the business was registered to trade register on 29.11.1968. Thus a company called Oy Saab Ab, which focused on producing Saab motor vehicles, was formed in the city of Uusikaupunki. Contract manufacturing for other car brands started already in the 1970s. Due to ownership arrangements in 1995, the company was named Valmet Automotive. (Valmet Automotive Oy, 2020)

Since 1990s, the Uusikaupunki car plant has been a leading user of manufacturing automation and robotics in Finland, and Valmet Automotive is considered a forerunner of production technology innovations nationwide. Investment on design and engineering services began in 1980s, and the company has focused on developing EV- and battery systems technologies for over ten years now. (Valmet Automotive Oy, 2020)

Picture 1 Valmet Automotive car manufacturing plant in Uusikaupunki.

3.2 Present Day

Since 2010 Valmet Automotive has grown and internationalized rapidly, and its car manufacturing plant in Uusikaupunki is the largest production facility in Finland based on the number of people it employs. In 2017 the car plant produced over 90 000 vehicles and raised cars among the most valuable exported goods of Finland.

Valmet Automotive operates in four European countries, and employs over 6000 automotive industry professionals across all its offices and places of operation. Out of all the employees, 1000 people are engineers working in design and engineering services, specialized in solutions for automotive, manufacturing- and battery systems.

Besides manufacturing vehicles for Daimler, Valmet Automotive also designs and manufactures kinematic systems, such as convertible roofs and active spoilers for Porsche, BMW, Bentley etc. Valmet Automotive's new EV Systems business line is manufacturing batteries for Avant Tecno electric loaders and is expanding its business to also manufacture batteries to electric vehicles. On top of manufacturing services, VA also provides design & engineering services for automotive and manufacturing industries.

Picture 2 Avant Tecno e6 - battery manufactured by Valmet Automotive.

3.3 Future

Valmet Automotive launched a new EV-battery manufacturing factory in Salo at the end of the year 2019. The new production plant diversifies Valmet Automotive's portfolio and provides another major business line in addition to vehicle manufacturing.

There is a heavy trend towards EVs in the future as all major car manufacturers are investing heavily in new EV-models and battery manufacturing capabilities. Being able to offer services for large-scale battery production and product development is a huge asset and business opportunity in the future for vehicle OEMs, such as Valmet Automotive.

3.4 Products

Valmet Automotive's main products are Mercedes-Benz A- and GLC-class vehicles manufactured for Daimler AG. VA began manufacturing vehicles for Daimler in 2013, starting with A-class model W176. In 2017 VA started manufacturing GLC-class SUVs along with A-class.

In 2018 Daimler updated and replaced their A-class vehicle with a new model W177, which VA also started manufacturing. In 2019 GLC received a facelift, which brought new engine options and hybrid models to production.

3.4.1 Mercedes-Benz A

Picture 3 Mercedes-Benz A-Class, W177.

A-Class is the premium compact car model from Daimler. It has been manufactured for over 20 years and has over 3 million units sold. The current 4th generation A-Class is manufactured in five car plants in Germany, Hungary, China, Mexico, and Finland. Aside from new design, it has a ton of technical improvements compared to the old model. (Daimler AG, 2020)

3.4.2 Mercedes-Benz GLC

GLC is Daimler's premium SUV, which first came to the market in 2015. The new facelift offers subtle exterior styling changes, such as a new grille, redesigned bumpers and LED-lights as standard. Inside the changes are more pronounced, with all digital displays, MBUX (Mercedes-Benz User Experience) infotainment system first seen in the W177, and a wide arrangement of driving aids. The new GLC also received several new engine options, with focus on 48V battery assisted "mild hybrid" versions. (MercedesBlog, 2019)

4 REFRIGERATION

4.1 Thermodynamical Basics

Thermodynamics is the physics of heat and its relationships with other forms of energy. The second law of thermodynamics states following: The entropy of an isolated system never decreases. The entropy either increases, until the system reaches equilibrium, or stays in equilibrium if the system began in that way. In other words, two systems of different temperatures interacting results in the hotter system spontaneously transferring heat energy to the cold system, not the other way around. (Knight, 2008)

Refrigeration is a process of cooling a place or matter. Used in a system it lowers or maintains its temperature below the surrounding one by removing heat. (International Institute of Refrigeration, 2020)

The process of refrigeration or air conditioning would seem to contradict the second law of thermodynamics by moving heat energy from cold air to hotter air. However, because the process requires external work to be put in the system in order for it to work, it no longer defies the rule. (Knight, 2008)

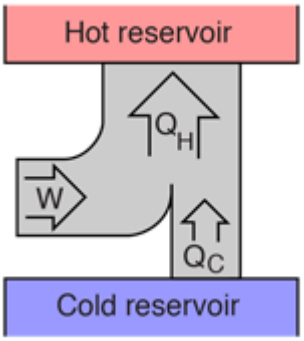


Figure 1 Heat pump energy transfer diagram.

Refrigerator is a closed-cycle system, which uses external work W to remove heat energy Q_C from cold reservoir and moves exhaust heat Q_H to hot reservoir.

Conservation of energy formula is the following.

$$Q_H = Q_C + W \quad (1)$$

, where Q_H= heat dissipated to the hot reservoir, J

Q_C= heat absorbed from the cold reservoir, J

W = external energy required, J

In other words, a refrigerator must exhaust more heat energy to the hot reservoir than it removes from the cold reservoir. (Knight, 2008)

The thermal efficiency of a refrigerator is defined by its coefficient of performance K, which can be derived by following formula:

$$K = Q_C/W \quad (2)$$

More efficient refrigerator can cool more with less energy consumption. (Knight, 2008)

A perfect refrigerator would require no external work, thus having infinite coefficient of performance, but such a device is forbidden by the second law of thermodynamics, because without any work input the heat energy would move from hot to cold. (Knight, 2008)

4.2 Automotive Air Conditioning

Automotive air conditioning was invented in 1939 by Packard and has been commercially available for motor vehicles since 1940. AC has worked the same way since beginning, cooling air and removing humidity from it. (Kristen Hall-Geisler, 2020)

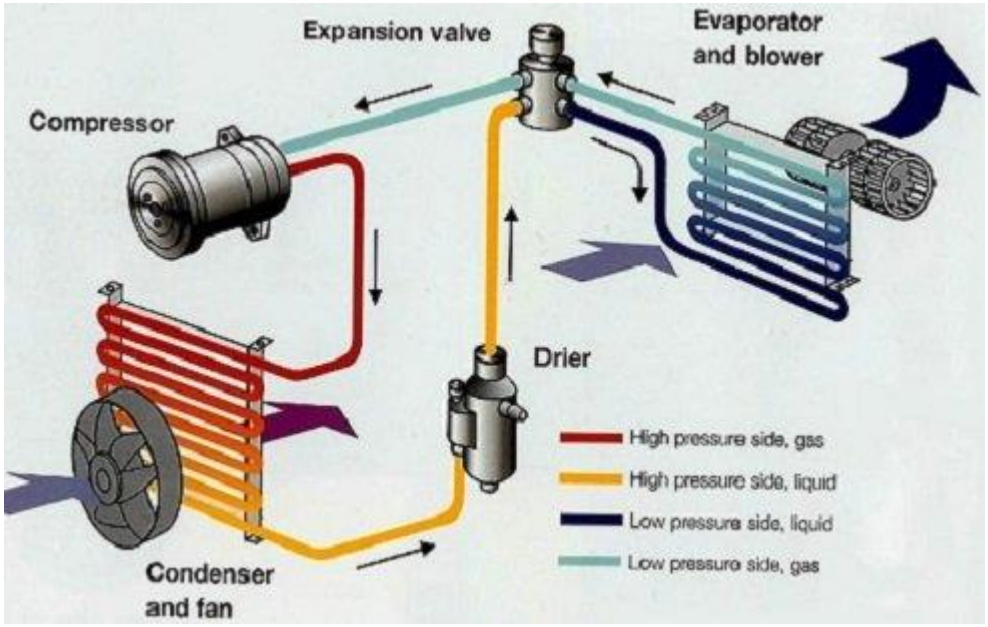
Automotive air conditioning is a closed loop system divided into two sides: high-pressure side and low-pressure side.

On the high-pressure side there are compressor, condenser and receiver-dryer. Compressor is a pump attached to the engine's crankshaft by a belt. It draws in the refrigerant gas and compresses it to high pressure, driving it to condenser. Condenser is a radiator, where the refrigerant gas is cooled down to form high pressure liquid. After

condenser, the liquid refrigerant moves to receiver-dryer tank containing desiccants, which absorb any possible water that has entered the system.

Dried refrigerant liquid enters low-pressure side depending on system via a thermal expansion valve or an orifice tube, which serve the same purpose. Flowing through it, the liquid expands, and pressure is reduced before entering evaporator. Expansion valve has sensors monitoring and regulating the flow rate, whereas orifice tube allows a constant rate of flowing without sensors moving parts. Low pressure refrigerant liquid enters evaporator at zero degrees Celsius, where due to low boiling point and the heat of the car cabin it boils and evaporates into gas again.

Refrigerant gas absorbs heat in the evaporator and moves back to the compressor. Evaporator absorbs humidity from the air as water condenses on the evaporator coil. Fan on the evaporator coil blows cool air into the car cabin, making passengers more comfortable. (Dürr Somac GmbH, 2018)



Picture 4 Expansion valve type AC system diagram.

4.3 Refrigerants

Generally, refrigerants are halogenated hydrocarbons, which contain chlorine and/or fluorine substituted in hydrocarbon chain. There are different types of refrigerants in automotive industry that have been used over the decades. Starting with Freon, which was eventually banned due to causing ozone layer depletion. Followed by R-134a,

which is still used in some countries today, and on to new class of refrigerants, such as R-1234yf and R-744.

4.3.1 R-12

Dichlorodifluoromethane (CF_2Cl_2)
R-12 known also as CFC-12 (chlorofluorocarbon), or commonly as Freon-12. (INCHEM, 2002)
Widely used CFC-based refrigerant, until the phasing out of high-GWP-value (Global Warming Potential) chemicals manufacturing due to Montreal Protocol in 1987, because of their ozone layer depleting and global warming properties. (Reasor;Vikrant;& Radermacher, 2010)
R-12 has remarkably high GWP-value of 10 900. (IPCC, 2007)

4.3.2 R-134a

1,1,1,2-tetrafluoroethane (CF_3CHF_1) also known as HCF-134a (hydrofluorocarbon). R-134a replaced R-12 in the early 90s in automotive refrigeration. High GWP-value of 1 430, despite being $1/8^{th}$ of R-12's value. (IPCC, 2007)
In 2019 R-134a was replaced in EU by R-1234yf in new vehicles. R-134a is still used in some market areas, such as US, China and Russia. (Reasor;Vikrant;& Radermacher, 2010)

4.3.3 R-1234yf

2,3,3,3-Tetrafluoropropene (CH_2CFCF_3), also known as HFO-1234yf (hydrofluoro-olefin).
R-1234yf replaced previous R-134a in EU due to European directive 2006/40/EC, which required mobile air conditioning units to use refrigerants that have GWP-value lower than 150. (The European FluoroCarbons Technical Committee, 2006)
R-1234yf has low GWP-value of 4, which is significantly lower than the previous generation refrigerants, as well as close thermophysical properties compared to R-134a,

making it an excellent replacement. Due to flammability and pressure differences in AC-systems, R-1234yf can't be used as a drop-in replacement for R-134a requiring separate filling equipment and conversion kits for existing systems. (Reasor;Vikrant;& Radermacher, 2010)

4.3.4 R-744

Carbon Dioxide (CO_2).

R-744 has GWP-value of 1 based on GWP's definition. Carbon dioxide based refrigeration systems have been in development along with R-1234yf and are making their way to automotive industry. High pressures (as high as 140 bar) and low critical temperature have posed design challenges, but they are expected to be adopted especially by EV's. (Kiiskinen, 2019)

5 FILLING MACHINE COMMISSIONING PROJECT

5.1 Project Management

The filling machine commissioning project took part in summer 2018 during Valmet Automotive's factory shutdown of three weeks. It divided into two sub-projects: relocation of an old filling machine from rework station to the main production line to meet the increased demand for R-1234yf-fillings; and installing and commissioning the new filling machine at the rework station to replace the old one. In addition, the project was affected by relocation of the rework station, which also happened during the shutdown.

The project can be split into following phases from VA's perspective as the customer receiving the machinery:

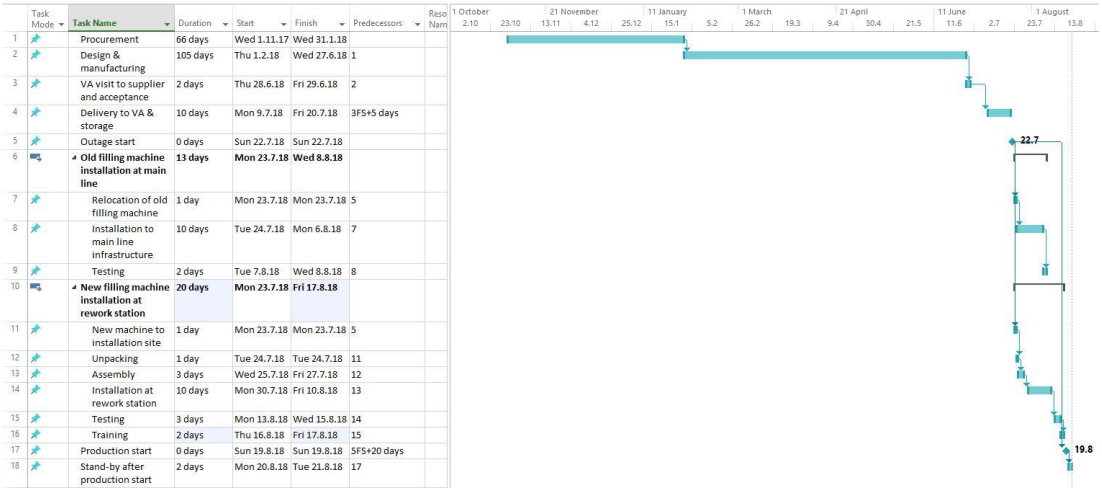
- Procurement.
- Design and information exchange together with machine supplier.
- Factory arrangements and preparations.
- Supervision of installations and commissioning.

5.1.1 Scheduling

Valmet Automotive's production was running in five shifts 24/7 from Monday to Saturday, so in order for the installation to be successful, it was critical that the filling machine was delivered on time before the factory shutdown starts, and the commissioning is finished before the shutdown ended. To ensure the timely manufacturing and delivery of the filling machine, a schedule of the project was delivered by the supplier to VA for inspection and follow-up.

The supplier schedule's activities of work performed at VA were merged to the general schedule of the factory shutdown, so critical path of the works happening during shutdown could be recognized and followed.

Table 1 Project Schedule.



	Task Mode	Task Name	Duration	Start	Finish	Predecessors	Resource Names
1		Procurement	66 days	Wed 1.11.17	Wed 31.1.18		
2		Design & manufacturing	105 days	Thu 1.2.18	Wed 27.6.18	1	
3		VA visit to supplier and acceptance	2 days	Thu 28.6.18	Fri 29.6.18	2	
4		Delivery to VA & storage	10 days	Mon 9.7.18	Fri 20.7.18	3FS+5 days	
5		Outage start	0 days	Sun 22.7.18	Sun 22.7.18		
6		**Old filling machine installation at main line**	**13 days**	**Mon 23.7.18**	**Wed 8.8.18**		
7		Relocation of old filling machine	1 day	Mon 23.7.18	Mon 23.7.18	5	
8		Installation to main line infrastructure	10 days	Tue 24.7.18	Mon 6.8.18	7	
9		Testing	2 days	Tue 7.8.18	Wed 8.8.18	8	
10		**New filling machine installation at rework station**	**20 days**	**Mon 23.7.18**	**Fri 17.8.18**		
11		New machine to installation site	1 day	Mon 23.7.18	Mon 23.7.18	5	
12		Unpacking	1 day	Tue 24.7.18	Tue 24.7.18	11	
13		Assembly	3 days	Wed 25.7.18	Fri 27.7.18	12	
14		Installation at rework station	10 days	Mon 30.7.18	Fri 10.8.18	13	
15		Testing	3 days	Mon 13.8.18	Wed 15.8.18	14	
16		Training	2 days	Thu 16.8.18	Fri 17.8.18	15	
17		Production start	0 days	Sun 19.8.18	Sun 19.8.18	5FS+20 days	
18		Stand-by after production start	2 days	Mon 20.8.18	Tue 21.8.18	17	

5.1.2 Meetings and Information Exchange

During the design and manufacturing period, the machine supplier was given Daimler's filling specifications for the vehicles. Information such as filling pressures, vacuum pressures, pressure leak values, filling amounts and tolerances, and filling times. AC-pipes and vehicle engine compartment dimensions were sent to the supplier, so they could design filling adaptors.

Also discussed were the information about installation site, like what were the necessary factory arrangements needed before the machine arrives, so smooth installation and commissioning were possible. Installation site location, CAD-layouts of the rework station including all the other machinery at the site, machine needs, such as power, data and ventilation connections, etc. were discussed and responsibilities shared.

Before the machine was shipped to VA, an approval visit to supplier's factory in Germany was arranged. The author and the head of maintenance from Assembly shop visited the factory, and the machine was deemed to meet VA's specifications. Some follow-up actions were drafted, such as further clarification for essential spare parts and new testing kits for maintenance.

Picture 5 W177 engine compartment space. AC-pipes on the left side highlighted in red.

5.1.3 Design

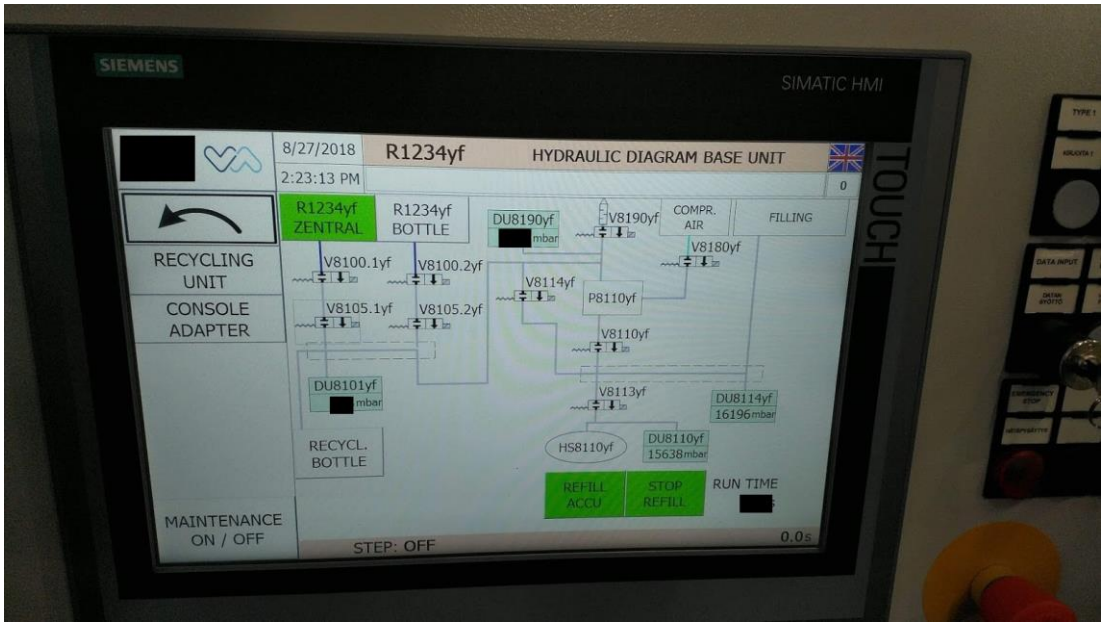
As the new filling machine was primarily designed for rework station use, some design choices deviating from the main line filling machines were implemented.

Key difference between the new machine and the old ones is the recycling unit, which allows the operators to empty a vehicle's AC-circuit and refill it, in case of incomplete or failed refilling process on the main line filling station. Recycling unit makes the physical size of the new filling machine considerably larger than the old one. Due to the larger size of the rework station machine and deviating design features, there is no longer need for it to be easily moveable, so it has no wheels under it.

The machine is also fitted with a separate AC-bottle supply, so in case there is a malfunction with mainline AC-supply connection, the rework station machine can still function. Similarly, the new machine uses pressurized nitrogen instead of pressurized

air in pressurization processes, which are also supplied in separate bottles instead on hard-line connection for added reliability.

Large physical size also allows the use of larger HMI-touch monitor, which makes adjusting operation parameters and inspecting flow circuits easier.



Picture 6 Larger HMI-monitor.

5.1.4 Factory Arrangements and Preparations

Some factory arrangements needed to be done before the filling machine arrived, so correct installation and operation were possible.

The machine needed electrical connection. Specifications dictated that a three-phase power connection was needed, so it was installed by a local electrical works company. Ventilation was needed, because the refrigerant medium produced flammable gas vapors inside the cabinet. Also due to the flammable gases, the ventilation pipes needed to be grounded. A local HVAC-company did the piping and grounding installations.
A working data connection was required. An unused Ethernet socket was found at the installation site, so IT-department allocated it for the new filling machine and set it up to communication specifications.

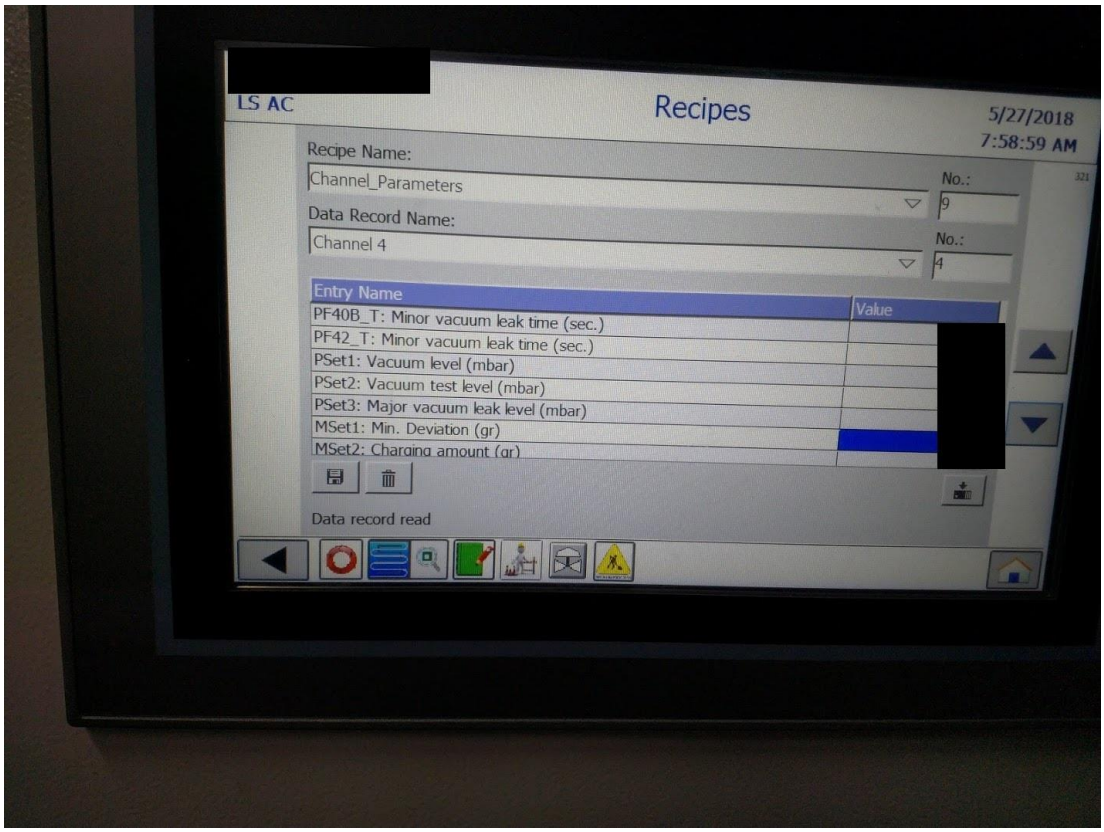
As the filling machine was delivered to VA storage before the factory shutdown, the machine needed to be delivered on-site for installation. Internal logistics services were used to deliver the machine from storage to installation site.
For testing, unfilled vehicles of different specifications were needed. Production department supplied the vehicles for testing.

5.1.5 Hunter Communication and Filling Recipes

For the filling machines to function properly, they need to communicate with the Hunter production management software. Hunter contains every vehicle's identity and information in production - for example which fillings a vehicle receives. Different vehicle configurations have different filling recipes, which dictate, how much certain mediums are filled with the particular configurations.

In the case of AC-fillings, Hunter gives the information, which AC-medium is used (R-134a or R-1234yf), which vehicle model is filled (A or GLC) and what is the filling amount (hybrid or non-hybrid vehicle).
After a scanner reads the ID-tag of the vehicle, Hunter returns the correct recipe value, which the filling machine interprets and automatically selects the right recipe to fill the vehicle with.

Hunter also stores the information about the filling process after the filling has happened. Did the filling process succeed, how much medium was filled, what where the pressures, how long did it take.



Picture 7 Example of AC-filling machine recipe.

5.1.6 Risk Assessment

Following risks were identified in the project, and mitigating actions were planned.

Table 2 Main Risks Identified in the Project.

Risk	Consequence	Corrective Procedures
New filling machine not working as intended.	Filling at rework station not possible. Possible loss of production.	Test fillings done with both production vehicle models. Commissioning engineer at stand-by during production start.
Old filling machine relocation fails.	Only one HFO-filling machine working at main production line. Possibility for missed fillings, if one machine can't keep up with production.	Gradual production ramp-up. Rework station ready for missed fillings. Commissioning engineer at stand-by during production start.
PLC-communication with Hunter not working.	Automatic filling process not possible.	Test fillings done to production vehicles with different options. Manual operation of machine possible. Commissioning engineer at stand-by during production start.
Rework station operators don't know how to operate new filling machine.	Possibility for incorrect fillings, damaging the machine or vehicles.	Training arranged for operators.
Maintenance personnel don't know how to service new filling machine.	Possible loss of production if machine breaks.	Training arranged for maintenance personnel.

5.2 Commissioning

The installation and commissioning work began after the factory shutdown started on 22.7.2018. The duration of the shutdown was four weeks, and during that time the successful installation, testing and commissioning of the new R-1234yf-filling machine was realized.

After a period of successful operation during regular production, assuming all the acceptance criteria were met, final acceptance of the machine would be granted.

5.2.1 Installation

Installation work begun on Monday 23.7.2018 by internal logistics transporting the new filling machine to the installation site at the rework station. At the same time maintenance team relocated the old filling machine to the main production line.

The next day two commissioning engineers from the machine supplier came in and started unpacking the machine. After the unpacking was done, the machine was ready to be assembled. Assembly lasted for rest of the week. After assembly was done, one of the commissioning engineers left to work on the old filling machine at the main line, after maintenance team had finished installing it.

Installation phase lasted for two weeks. During installation the machine was connected to power, ventilation, Ethernet, and supplied with nitrogen. Internal circuits were tested, and HMI-functionality was checked. Failure mode functions and gas alarm systems were checked. Ventilation functionality in normal operation and during gas alarm were checked.

After normal operation of the machine was ensured, it was supplied with R-1234yf-bottle, and functionality tests continued. Filling parameters and values were adjusted and saved.

Finally, data connection to Hunter was tested, and PLC-programming was fine tuned. After the machine was functioning as intended, the testing phase was ready to commence.

Picture 8 Filling machine in the middle of installation.

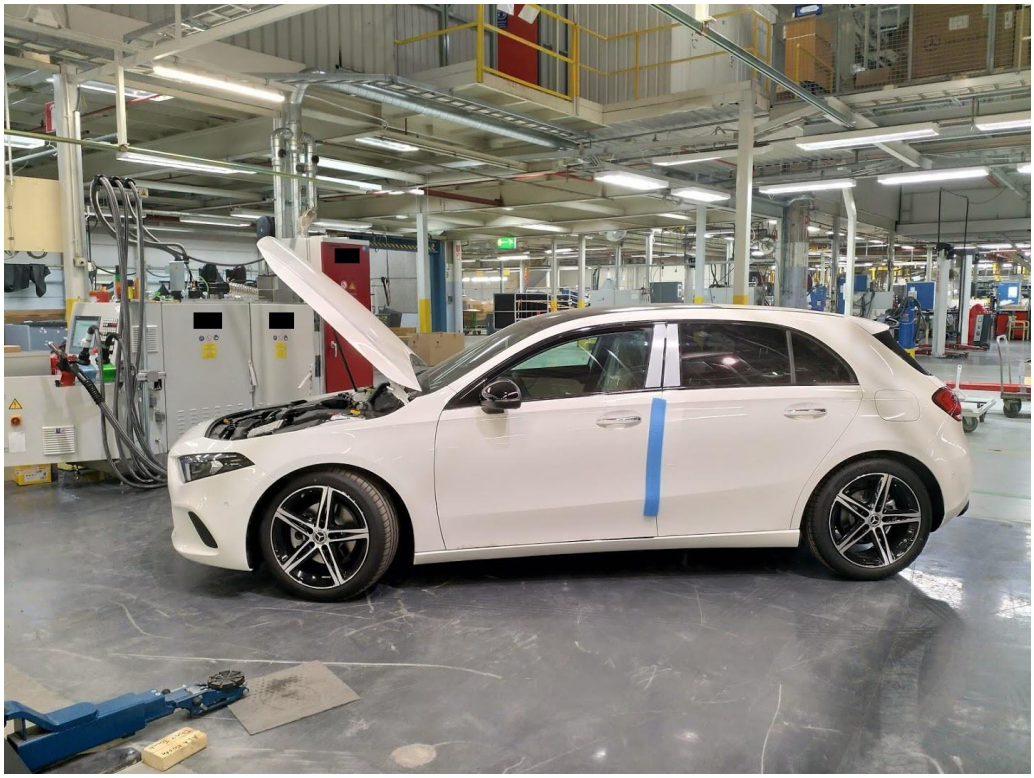
5.2.2 Testing

Final week of the shutdown was reserved for testing and training. For testing phase, two A-Class and two GLCs were reserved and left unfilled by production department. First, basic filling functions were tested. Filling worked perfectly with test bottles and vehicles reserved for testing.

After filling, recycling functions were tested. In recycling mode, the machine sucks out the refrigerant out of the AC-pipes and stores it in the recycling bottle inside the unit, ready to be used again. Recycling unit was also functioning with the test vehicles.

Finally, vehicle and recipe recognition with Hunter were tested to ensure automatic operation of the filling process.

After the filling machine was confirmed to be fully functional and ready for operation in production, the maintenance and rework station personnel were trained to use and maintain the filling machine.



Picture 9 W177 at rework station ready for testing.

5.2.3 Acceptance

Acceptance criteria for the new rework station AC-filling machine were the following:

1. The machine is installed, tested, commissioned, and it functions as designed during production.
2. Critical spare parts are identified, ordered and delivered to VA.
3. Operators and maintenance personnel in all shifts are trained to use and maintain the machine.
4. All documentation (operation and maintenance manuals, PLC-copies, etc.) are delivered to VA.

All the acceptance criteria were met, and after the machine had been running in normal production conditions for two weeks without issues, it was granted final acceptance.

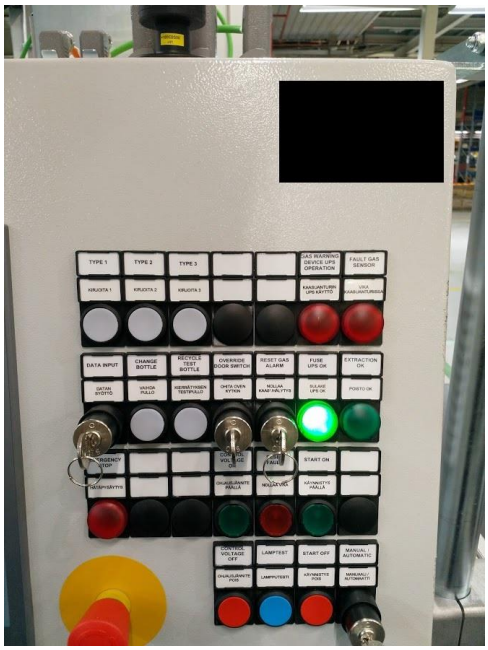
5.3 User Experiences

People working on the rework station had no issues with the new AC-filling machine. They were all trained to use it, and operationally it was similar to the previous AC-filling machine, with the exception of the new recycling unit, which the old machine didn't have.

Maintenance workers also received training to maintain the machine. For maintenance, the separate AC-bottles and nitrogen bottles brought extra work, because they need to swap them to new ones when the old ones were empty. Their wish was to hook the machine to main lines to get rid of the extra work, but the added reliability of being separate from the main line was decided to be worth it.

Operation of the AC-filling machine is simple. The vehicle's barcode is read with a scanner and the machine selects the correct recipe automatically. There is no need for the workers to use or change the machine's settings in the HMI-monitor. The monitor is meant to be used in adjusting the filling parameters or during maintenance work.

In the case of connection issues with Hunter, the new machine is also equipped with easy-to-use manual panel, which is similar to the other filling machines.



Picture 10 Filling machine manual interface.

6 CONCLUSIONS

The project was deemed successful. The relocation of old R-1234yf-filling machine from rework-station to main line filling station succeeded without problems. As there was already infrastructure built for the machine previously, it only needed to be transported to the new site, be connected to the existing systems, and tested that everything was functioning.
The new rework station filling machine commissioning was also a success. Due to effective planning and communication, all the critical factory arrangement needs and machine specifications were identified and completed on time. The installation and commissioning work were also finished without issues.

By doubling the capacity of R-1234yf-refrigerant filling machines on the General Assembly main production line filling station, Valmet Automotive has taken steps to being able produce more environmentally friendly vehicles for Daimler AG. Having a filling machine in the rework station capable of recycling the refrigerant gas will also have minor positive impact on environment.

The usage of R-1234yf-filling machines will only increase in the future as by model year 2021 all new vehicles in the United States will replace R-134a with low GWP-refrigerant alternatives, such as R-1234yf. (EPA United States Environmental Protection Agency, 2015)
Japan joins the trend in 2023, and China is to follow in coming years. It has been estimated that a market area transitioning from one refrigerant to a more environmentally friendlier one takes roughly 6-8 years. (Du;Meszler;& Minjares, 2016)

This capacity increase project allows Valmet Automotive to produce consecutive R-1234yf-vehicles non-stop, so they are well prepared for more markets adjusting to environmentally friendlier vehicles.

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