Miljø- og
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Miljøstyrelsen

Udvikling af serviceudstyr til håndtering af alternative kølemedier til bilers Aircondition

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1 Indhold

2 Forord

Klimaforandringen er blandt de største globale miljøudfordringer, hvis ikke den største, som menneskeheden i dag konfronteres med. Det er derfor nødvendigt at gøre en aktiv indsats for at reducere påvirkningen af drivhusgasserne og samtidig søge alternativer til de i dag kendte og brugte kølemidler.

Substitution af drivhusgasser inden for bil-, aircondition- og køle-/fryseindustrien er i proces, men er ligeledes på meget forskellige stadier, med meget forskellige tidshorisonter. Bilindustrien samt de kommercielle køleanlæg er i gang med at gennemgå konvertering i første fase.

AGRAMKOW har omfattende erfaringer fra tidligere omlægninger af produktionsanlæg til nye kølemidler – senest omlægning fra R134a til Isobutan, hvor AGRAMKOW har bistået 30-50% af verdens køleskabsfabrikker.

I bilindustrien er der efter lang tids undersøgelse og "kamp" endeligt valgt et kølemiddel. Dette kølemiddel har den tekniske betegnelse R1234yf (eller HFO1234yf) og det er planen at kølemidlet skal anvendes i hele verdenen.
I modsætning til CO2 har dette kølemiddel egenskaber der ligger meget tæt på det nuværende kølemiddel R134a, dog er der to væsentlige forskelle: Kølemidlet har en GWP (Global Warming Potential) på kun 4 mod de nuværende 1300 for R134a og kølemidlet er brændbart.

3 Sammenfatning og konklusioner

3.1 Forord

Alternative kølemidler til Mobile Air-conditioning (MAC), har et højt fokus blandt udviklingsafdelingerne verden over. Et af alternativerne var i lang tid CO2 men efter lang tids undersøgelse er R1234yf nu blevet valgt af bilindustrien som det foretrukne kølemiddel. Den primære tekniske udfordring i anvendelse af dette kølemiddel er at kølemidlet er brændbart og nuværende maskiner/service stationer kan/må derfor ikke anvendes.

MAC er ikke det eneste sted hvor R1234yf er et alternativ. P.g.a. kølemidlets identiske egenskaber med R134a undersøges det også hvorvidt kølemidlet kan anvendes i almindelig husholdnings køl, udfordringen er imidlertid at kølemidlets kostpris forventes at blive meget høj og det kan derfor være en væsentlig forhindring i indførelse af R1234yf i husholdnings køl.

AGRAMKOW Fluid Systems A/S har altid været i front ved udvikling af industrielt/service udstyr til håndtering af nye kølemidler og processer – R1234yf er ingen undtagelse.

3.2 Processen

Da AGRAMKOW Fluid Systems A/S i begyndelsen af 2002 for alvor begyndte at udvikle fyldeudstyr til alternativ kølemiddel blev der i lang tid satset på CO2. Da CO2 har væsentligt andre egenskaber en det traditionelle R134a blev det hurtig klart, at de hidtidige kompetencer, know-how samt netværk ikke kunne bidrage med den teknologiske indsigt. Hertil var hele processen samt teknologien for uafklaret, respektive så forskellig fra den kendte teknologi, at det var nødvendigt at starte forfra.

Der blev derfor i tidsperioden 2002 til 2009 arbejdet intensivt med udvikling af CO2 teknologi til både produktionsanlæg samt service. Retningen af denne udvikling blev bekræftet to gange af VDA (Verband Deutche Automobilindustrie), første gang i 2007 og igen i 2008. Imidlertid skete der i foråret 2009 en meget uventet drejning hvor den samlede Tyske bilindustri (som var fortalere for CO2) begyndte at investere betydelig R&D ressourcer i undersøgelse af R1234yf.

Omkring Maj 2009 blev der derfor i AGRAMKOW initieret et udviklingsprojekt der havde til formål at udvikle service stationer til det nye kølemiddel R1234yf. Den endelige beslutning kom først omkring sommer 2010 hvor den Tyske bilindustri (meget stille) meldte ud at R1234yf vil blive det fremtidige kølemiddel, ikke kun for den Tyske bilindustri men globalt.

Selv om AGRAMKOW's mange års erfaring indenfor brændbare kølemidler er blevet anvendt har det til tider ikke været tilstrækkeligt. Det var derfor i højere grad end sædvanligt påkrævet, at etablere videns netværk og indgå

samarbejdsaftaler. Den tidlige beslutning omkring teknologiskift (1 år inden officiel udmelding fra VDA) har betydet at vi i dag står stærkt rustet i forhold til vores konkurrenter, både på de rene kompetencer, såvel som vores produktprogram. Hele processen har derfor været til stor gavn for både AGRAMKOW samt de samarbejdspartnere som har deltaget.

3.3 Produktet

Selve produktets funktionalitet (proces) er ikke så meget anderledes end på et nuværende R134a produkt. Oplevelsen for en bruger forventes blive en smule anderledes pga. kølemidlets brændbarhed som vil kræve skærpet krav til sikkerhed. Denne klassificering af kølemiddelet vil i fremtiden betyde en anderledes håndtering omkring værkstedet, forsyningskæden, affaldsproblematikken etc. Der er derfor stadig i dag en stor usikkerhed blandt konkurrenter, leverandører og kunder hvad dette helt nøjagtigt betyder.

Ligeledes er der ved flere leverandører (som f.eks. kompressor leverandører) stadig intensive test, specielt omhandlende kompressor oliens forbindelse med fugt. Dette forventes at blive et kritisk tema som allerede har smittet af på krav til service udstyret.

Der forventes samtidigt at der i den europæiske service industri vil opstå et mindre kendt fænomen som imidlertid er meget velkendt fra USA. Ved indførelse af nyt kølemiddel vil der uden tvivl forekomme hvad man i USA kalder ”cross contamination” – altså en forurening mellem det nuværende R134a kølemiddel og det nye R1234yf kølemiddel. Denne forurening kan ske enten som et uheld eller helt bevidst fordi kostpris på det nye kølemiddel forventes at blive meget højt. Dette er specielt et problem med R1234yf fordi kølemidlets egenskaber ligger meget tæt på R134a og slutkunden vil derfor ikke kunne mærke forskel på ydeevnen af klima-anlægget efter service.

Produktet er derfor udviklet til at specielt imødegå de sikkerhedsmæssige udfordringer omkring brændbare kølemidler men samtidigt også tage højde for de tekniske udfordringer der er omkring olie, nøjagtigheder, forurening etc.

Der er fra VDA samt den amerikanske organisation SAE blevet udarbejdet specifikationer og standarder der beskriver produktets ønsket funktionalitet samt krav til sikkerhed. AGRAMKOW har siddet med i arbejdsgrupperne ved både VDA og SAE.

3.4 Markedet

Markedet er ved at blive mere konkret, specielt med henblik på udvalget samt tilgængeligheden af komponenter og markedet for MAC service udstyr forventes at resulterer i betydelige salgsoptioner over de næste 10 år.

Markedet samt holdningerne til R1234yf har været meget kompleks samt fluktuerende under processen, hvilket ligeledes har givet sig til udtryk i projektet. Det var herunder svært at få afklaret hvornår og i hvor høj grad bilindustrien ville omstille deres produktion. Samtidig var hele teknologien meget uklar, hvilket ligeledes forplantede en hvis usikkerhed under opstartsfasen af dette projekt.

AGRAMKOW startede med udviklingen af R1234yf service station med det fokus at produktet skal gå i volumenproduktion. Imidlertid forventes det ikke at volumenproduktion starter før medio 2011 og det første markedsfokus har derfor været bilindustriens udviklings- og testafdelinger samt leverandører til bilindustrien. De første prototyper startede i field test ved VW koncenen i Tyskland i September 2009. Derefter har både Audi, BMW og Daimler fået prototyper til test. Prototypen har p.t. ved VW fungeret i mere end et år med jævnlige tilpasninger og justeringer.

Alt taget i betragtning, tyder AGRAMKOWS beslutning om dette hurtige skift fra CO2 til R1234yf som alternativt kølemiddel, på at være en stor succes. Via dette projekt har vi således indarbejdet nye kompetencer i virksomheden samt etableret nye kontakter og videns netværk. Herudover er det også lykkedes at anvende den opbyggede viden indenfor AGRAMKOW's industrielle segment som er fokuseret på bilfabrikkernes fyldeudstyr.

AGRAMKOW forventer sig derfor meget at R1234yf satsningen og glæder sig over de allerede realiserede salgsordre og de gode erfaringer

4 Summary and conclusions

4.1 Introduction

Alternative refrigerants in Mobile Air-conditioning (MAC) have high attention among development teams worldwide. One of the alternatives was a long time CO2 but after long study is R1234yf now been chosen as preferred automotive refrigerant. The primary technical challenge in using this refrigerant is that this refrigerant is flammable and current machines/service stations may not be used.

MAC is not the only segment where R1234yf is an alternative. Due to the identical properties with R134a it is also investigated whether the refrigerant can be used in everyday household refrigerator, the challenge is that the refrigerant cost expected to be very high and therefore it may be a major obstacle in using it in this area.

AGRAMKOW Fluid Systems A / S has always been at the forefront in the development of industrial / service equipment for handling new refrigerants and processes - R1234yf is no exception.

4.2 The process

When AGRAMKOW Fluid Systems A/S in early 2002 began to develop charging equipment for alternative refrigerants there were for a long time invested in CO2. Since CO2 has significantly different characteristics a traditional R134a it soon became clear that the previous skills, know-how and the network could not provide the technological insight. Furthermore, the entire process and technology were so different from the known technology that it was necessary to start over.

In the time period from 2002 to 2009 AGRAMKOW worked intensively on developing CO2 technology for both production and service. The direction of this development was confirmed twice by the VDA (Verband Deutsche Automobilindustrie), the first time in 2007 and again in 2008. However in the spring of 2009 a very unexpected situation aroused when the entire German automotive industry (which were proponents of CO2) started to invest significant R & D resources in the study of R1234yf. On this basis,

AGRAMKOW initiated a development project, in May 2009, which aimed to develop service stations for the new refrigerant R1234yf. The final decision came around summer 2010 when the German car industry (very quietly) declared that R1234yf will be the future of refrigerant, not only for the German car industry but globally.

Although AGRAMKOW's many years of experience in flammable refrigerants have been used, it has sometimes been insufficient. It was therefore required to establish knowledge networks and form relationships. The early decision about

technology shift (1 year before the official announcement from VDA) has meant that today AGRAMKOW are well prepared compared to our competitors, both in competence, as well as product range. The whole process has therefore been of great benefit to both AGRAMKOW and the network partners who have participated.

4.3 The product

The actual product functionality (process) is not much different than on a current R134a service unit. The user handling is expected to be a bit different because the flammable characteristics of the refrigerant which will lead to more stringent security requirements. This classification of flammable refrigerant will in the future mean a different handling from: workshop, supply chain and waste handling. There is still today a great deal of uncertainty among competitors, suppliers and customers what this exactly will mean.

Also, there are a number of suppliers (such as compressor suppliers) still performing intensive tests, specifically dealing with compressor oil and problems with moisture. This is expected to be a critical issue which has already evolved into new demands for service equipment.

It is expected that a new and lesser known phenomenon will arise in the European services industry. This phenomenon is well known from the U.S. The introduction of new refrigerant will undoubtedly lead to what in the U.S. is called "cross contamination" - i.e. a contamination between the current R134a refrigerant and the new R1234yf refrigerant. This contamination can occur either accidentally or deliberately because the cost of the new refrigerants is expected to be very high. This is especially a problem with R1234yf because the refrigerant properties are very close to R134a and the end customer will not notice any difference in performance of the air conditioner after service.

The product is designed to specifically address the security challenges around flammable refrigerants but simultaneously also address the technical challenges there are about oil, accuracies, pollution etc.

VDA and the American organization SAE has worked out specifications and standards that describe the product desired functionality and safety requirements. AGRAMKOW have been participating in working groups of both VDA and SAE.

4.4 The market

The market is becoming more concrete, especially looking at the selection and availability of components and the market for MAC service equipment is expected to result in significant sales options over the next 10 years.

Market and opinions towards R1234yf has been very complex and fluctuating during the process. This is also reflected in the project. It has been difficult to clarify when and to what extent the automobile industry would change their production to the new refrigerant. At the same time, the whole technology is very unclear, which has also spread an uncertainty if the initial phase of this project.

AGRAMKOW started developing R1234yf service station with the focus that the product will go into volume production. However, it is not expected that volume production will start before mid-2011 and the first market focus has therefore been the industry's development and test departments as well as automotive suppliers. The first prototypes started in the field test by VW in Germany in September 2009. Thereafter, Audi, BMW and Daimler received prototypes for testing. The prototype at VW has now worked for more than one year with regular adjustments and refinements.

All things considered, the the AGRAMKOW decision about a rapid shift from CO2 to R1234yf as an alternative refrigerant seems to be a great success. Through this project, we have incorporated new skills into the company and established new contacts and knowledge networks. In addition, it is also possible to apply the knowledge generated within AGRAMKOW's industrial segment which is focused on factory equipment.

AGRAMKOW expect a lot from the R1234yf investments and are satisfied that this has already leaded to sales orders as well as improved know-how and experience.

5 formål

Som resultat af lovgivningen (2006/40/EG) vedr. Udfasning af HFC i bilers aircondition anlæg ønsker AGRAMKOW Fluid Systems A/S at udvikle et prototype produkt til servicering af klimaanlæg med R1234yf som kølemiddel. Service enheden vil dække de opstillede krav fra bilindustrien og samtidig imødekomme de europæiske sikkerhedskrav til brændbare gasser.

I forbindelse med udviklingen forventes det at teknologier, koncepter og metoder vil have afsmittende effekt på andre teknologiområder indenfor AGRAMKOW's produktområde.

De miljømæssige aspekter forbundet med projektet vil være store, i takt med konverteringen af bilproducenternes biler. I den forbindelse har R1234yf et GWP på 4, hvorimod det i dag benyttede kølemiddel, R134A, har et GWP på 1300. Samtidig har projektet en mulighed for at brede sig til andre segmenter - alle med store miljømæssige forbedringsmuligheder:

- Appliance marked: Køle- / fryseskabe.
- Aircondition (stationær).

I disse segmenter er det dog usandsynligt at R1234yf bliver indført før prisen på R1234yf nærmer sig prisen på R134a eller at producenterne bliver tvunget til kølemiddelskift via lovgivning.

6 Projektets parter

6.1 AGRAMKOW Fluid Systems A/S

AGRAMKOW har igennem 25 år oparbejdet en omfattende viden om håndtering af kølemidler og andre væsker i industrielle process-anlæg. Kundegrupperne omfatter bilfabrikker, køleskabs- og airconditionfabrikker, hvortil AGRAMKOW leverer komplette løsninger til påfyldning af kølemidler og andre væsker på biler, aircondition, køleskabe etc.

Herudover indbefatter AGRAMKOWs produktprogram ligeledes ITS udstyr (Information and Test system) hvilket indebærer EST (Electrical Safety Testers), CPT (Computerrized Performance Test Systems) og avanceret software til dataopsamling samt kontrol af hele testprocessen for køleskabs- og fryseindustrien.

AGRAMKOW Fluid Systems A/S har været ISO9001 certificeret siden 1996 og ISO 14001 siden 1999. Miljøcertificeringen startede oprindeligt som et kundekrav fra førende bilproducenter. I dag er miljøarbejdet blevet en af vores nøgleparameter som stadig får et større fokus. Som resultat heraf fik AGRAMKOW i 2001 og 2005 tildelt diplom og flag for en ekstraordinær Miljø- & Arbejdsmiljøindsats.

6.2 RTI Technologies

Eet af AGRAMKOW's datterselskaber er RTI Technologies som er en virksomhed baseret i York Pensylvania USA. Virksomheden er en 100% AGRAMKOW ejet virksomhed der har sit primære markedsfokus på "Aftermarket equipment", altså ustyr til værksteder med de primære markeder i USA og Canada.

RTI har tidligere udviklet udstyr til servicering af Aircondition anlæg i biler og senest har RTI udviklet et AC service udstyr der møder den amerikanske J2788 standard. Denne standard er en "opstramning" af tidligere krav, specielt på det miljømæssige område. De væsentlige parametre for J2788 standarden er udstyrets evne til at genindvinde brugt kølemiddel, rense det og påfylde det med stor nøjagtighed.

Disse parametre er alle en miljømæssig forbedring sammenlignet med tidligere standarder i USA. I Europa findes der ikke nogen EU/national standard der sætter krav til udstyrets performance og dermed heller ikke til udstyrets miljømæssige påvirkninger.

Samarbejdet med RTI har været særdeles gavnligt da eksperticen fra tidligere R134a service udstyrs udvikling er blevet kombineret med AGRAMKOWS viden og ekspertice indenfor brændbare kølemidler.

6.3 TÜV Nord

Som konsulentvirksom med speciale i brændbare gasser har AGRAMKOW arbejdet tæt sammen med TÜV Nord. Dette samarbejde har været særdeles vigtigt under hele udviklingen og der er anvendt betydelige ressourcer på fortolkning og forståelse af de gældende standarder og direktiver der er indenfor dette område.

TÜV Nord har været gode til at korrigere udviklingen både når de tekniske løsninger var underdesignet men også i de tilfælde hvor løsningerne var overdesignet. TÜV har ligeledes assisteret med at tolke lovgivning, standarder og regulativer med det mål at opnå kosteffektiv løsning der imødekommer alle sikkerheds- og lovgivningsmæssige krav.

Da kølemidlet, som før nævnt, er brændbart har AGRAMKOW naturligvis anvendt sin mangeårige viden indenfor dette område. Imidlertid er AGRAMKOW's hovedsegment produktionslinjer hvor produktet der her skal udvikles henvender sig til service markedet. Det betyder at der er andre sikkerheds foranstaltninger og i modsætning til industrimarkedet er service markedet under et meget større prismæssigt pres.

6.4 Volkswagen

VW var én af de første store OEM'er i Tyskland som initierede en egentlig udvikling med dette nye kølemiddel. Via AGRAMKOW's relationer på industrielt fyldeudstyr til produktionslinjer blev AGRAMKOW kontaktet af VW som udviste interesse for samarbejdet. Samarbejdet har ført til flere væsentlige forbedringer i produktet og udover de tekniske diskussioner og feed-back fra VW har det givet AGRAMKOW en indsigt i markedstiming der har medvirket til en forbedret udviklingsplan for projektet.

P.g.a. de tidlige aktiviteter indenfor dette kølemiddel har det dog ikke været muligt at samarbejde med "Aftermarket afdelingerne" da disse afdelinger først bliver sat ind i de nye teknologier på et senere tidspunkt. Imidlertid har samarbejdet fungeret godt med gensidig udvekslinger af tekniske krav og løsninger.

VW er desuden medlem i VDA arbejdsgruppen omkring service stationer til R1234yf

7 Projekt- & Produktspecifikationer

I det følgende beskrives de krav som har ligget til grund for udvikling af en mobil R1234yf service station til automobil service-industrien, baseret på de daværende sparsomme oplysninger som var givet fra bilindustrien (VDA), Dupont Honnywell samt den amerikanske SAE organisation.

7.1 Overordnet kravspecifikation

I modsætning til tidligere projekt omkring CO2 har bilindustrien været særdeles tilbageholdende med informationer, krav og oplysninger generelt. Dette skyldes at den tyske bilindustri gentagne gange har udråbt CO2 som værende det sikre og klimamæssige rigtige kølemiddel. Selvom kølemidlets miljørigtige sammensætning (GWP<4) har de tyske miljøinstitutter samt andre "globale" miljø- og sikkerheds aktører i lang tid opponeret mod R1234yf. Dette skyldes at kølemidlet er brændbart og når det brænder, udskiller kølemidlet meget farlige substanser såsom flussyre.

På baggrund af denne tilbageholdende adfærd har det i første omgang været nødvendigt for AGRAMKOW selv at opstille de tekniske krav til service stationen. Ligeledes har det været en stor del af opgaven at omsætte fortolkninger af ATEX direktivet, maskindirektivet samt bilindustriens forventninger til håndfaste krav der efterfølgende er mulige at implementere.

Efterfølgende (og meget sent i processen) har bilindustrien selv opstillet en detaljeret kravspecifikation der stiller yderligere krav til udstyret – primært indenfor produktets ydeevne og sikkerhed.

I det følgende vil de oprindelige overordnede tekniske krav blive beskrevet

7.2 Tekniske krav til service udstyr:

1. Skal overholde 2006/40/EG som er hovedårsagen til introduktion af det nye kølemiddel – dermed være i stand til at anvende det nye kølemidel
2. Sikkerhed skal designes iht. ATEX regulativet i Europa samt overholde gældende lovgivning udenfor Europa
3. Skal overholde maskindirektivet
4. Skal være mobilt og skulle kunne installeres på et værksted uden større ændringer i værkstedsindretningen
5. Produktets ydeevne skal overholde den amerikanske SAE2788 standard

Efterfølgende har den tyske sammenslutning af bilfabrikanter, VDA, udfærdiget en kravspecifikation der stiller øget krav indenfor følgende områder:

1. Sikkerhed for produktet i slukket tilstand
2. Kølemiddel identifikation (option)
3. Vakuum niveau og overvågning
4. Fylde nøjagtighed ved forskellige omgivelsestemperaturer
5. Genindvindings nøjagtighed

6. Udblæsning af ikke kondenserbare gasser
7. Eliminering af eksplosionsfarlige zoner

7.3 Koncept

AGRAMKOW sikkerheds-/servicekoncept (se bilag C) er designet således at en sikker servicering af bilens MAC kan gennemføres ved anvendelse af kølemidlet R1234yf. Sikkerheds-/servicekonceptet er primært rettet mod det Europæiske marked dog er der samtidigt forsøgt at imødegå krav fra lande udenfor EU.

I løbet af projektet er der anvendt betydelige ressourcer på at opstille forskellige koncepter, analysere disse koncepter og ud fra konklusionen vælge det beskrevne koncept. Ved nogle af de første koncepter der blev udviklet blev AGRAMKOW's erfaring indenfor brændbare gasser til brug ved fabriksinstallationer anvendt men det viste sig efter nogen tid at AGRAMKOW's viden på dette område kunne/skulle videreudvikles for at udvikle et produkt der var velegnet til brug på automobilværksteder.

Specielt eet forhold er anderledes mellem værksteder og fabrikker og det er den aktuelle mængde af kølemiddel der kan være til stede på et givent tidspunkt. Ved fabrikker er denne mændge opgjort i ton hvorimod på et bilværksted er mængden begrænset til ca 10 kg. Dette forhold gør i sig selv at risikoen af anvendelse af det brændbare kølemiddel skal revuderes.

For at imødegå ATEX 94/9/EC og 99/92/EC regulativerne skal installationen imidlertid godkendes af lokale myndigheder inden ibrugtagning. For at assistere denne godkendelse kan AGRAMKOW's udarbejdede sikkerhedskoncept med fordel anvendes.

7.4 R1234yf Proces sekvens

Ved en service skal service enheden gennemgå følgende processer. Fælles for alle processer er at ydeevnen skal være iht. SAE J2788:

1. (option) Kølemiddel identification. Kølemidlet i bilens MAC skal identificeres inden service enheden "tillader" at genindvinde bilens kølemiddel. Hvis der er en urenhed større end 5% må service enheden ikke tillade denne genindvinding.
2. Genindvinding af bilens kølemiddel. Indenfor 30 minutter skal service enheden have indvundet mere end 95% af bilens kølemiddel, renset det for fugt og urenheder og akkumuleret kølemidlet i service enhedens interne opbevaringstank (cylinder).
3. Evakuering ned til under 5 mBar absolut tryk i 30 min – herunder check af lækage vha. vakuum overvågning.
4. Forfyldning (Pre-charge). MAC fyldes med 50 gram kølemiddel og tryk overvåges i 5 minutter. Dette er en tryktest for at finde eventuelle lækager.
5. Genindvinding af forfyldning. De 50 gram fra forfyldning genindvindes.
6. Fyldning af bilens MAC med forudbestemt fyldemængde.

Under denne proces skal udslip af kølemiddel minimeres således at muligheden for brændbare zoner minimeres. Ligeledes vil der under processen være styret ventilation der sikre at ATEX imødekommes. Denne proces afspejler i høj grad processen som anvendes ved anvendelse af R134a, imidlertid er krav til

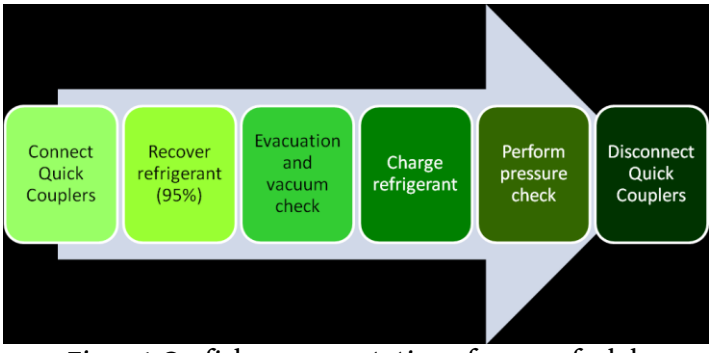
produktets ventilation samt tekniske løsning interne meget anderledes. Disse løsninger beskrives under afsnittet 7.6

7.5 Operatør sekvens

Når en R1234yf service station skal anvendes på værkstedet skal operatøren gennemgå følgende process.

1. (option) Monter kølemiddel identifikation's koblingen på bilens højtryks service studs (for aircondition anlægget). Initier analyse proces på service enheden. Hvis analysen er accepteret fortsæt med egentlig service.
2. Monter høj- og lavtrykskoblinger fra service slanger på bilens høj- og lavtryks service studser
3. Initier automatisk service process. Operatøren kan overvåge resulateter af de enkelte service trin i processen hvis ønskeligt.
4. Et akustisk signal indikerer slut af process for operatøren
5. Operatøren afmonterer servicekoblinger og udprinter service rapport på enheden
6. Service er afsluttet.

Der må under service ikke være tændkilder i en radius af 1 meter rundt om service koblingerne – Zone 2 iht. ATEX skal være opfyldt.



Figur 1 Grafisk repræsentation af proces forløb

7.6 Teknisk løsning

7.6.1 Monitoring

7.6.1.1 Ventilation of the service unit
The concept is based on a specific ventilation of the purge from the unit according to EN60079-10. The flow is therefore monitored via a Flow sensor. If correct flow is not achieved, operation is not possible.
The interior of the cabinet is assessed to Zone 2. According to EN60079-15 the protection types nA. nC, ic and ib are used for this Zone.

7.6.1.2 Ventilation System of car repair area
The area of the car-air conditioner can be chosen to be a Zone 2- or a non-hazardous area, depending on the chosen ventilation capacity for the car area.
It is the user's responsibility to assure that the necessary ventilation, according to the chosen concept, is achieved, before operation is permitted. According to EN60079-10 the ventilation availability only needs to be acceptable at a certain capacity to classify to non hazardous, wherefore a flow sensor and gas alarm is not necessary.

7.6.2 Necessary signals for operation permission

- Activated purge Flow sensor
- Non activated Emergency Stop/ Overall Emergency Stop.

7.6.3 Safety at standby

1. The interior (mechanical section) of the service unit is also during standby Zone 2. During standby all power to the mechanical section is off – thus there are no ignition sources left in the cabinet. When no ignition sources are present, and the unit is not in use, the ATEX directive doesn't apply.

2. The service unit can contain up to 22kg of refrigerant. EN378-1 table C.1 specifies the maximum allowable charge of a system compared to a specific room size. Demand of minimum room size must be evaluated by local authorities.

7.6.4 Safety at startup

1. Power to the on board Ventilation system is activated from the power sensor of the service unit.

2. The control and the power-sensor for starting the fan is defined as a non-hazardous Zone by the following concept: during stand-still, ventilation holes in the bottom assure that any possible leakage cannot create an explosive atmosphere at this point.

3. The power supply of the unit is situated in the same place as the power sensor – therefore same considerations as above

7.6.5 Safety during operation

7.6.5.1 Generally
All tubes in which liquid may be trapped must be equipped with safety valves according to EN378-1.

Ventilation capacity is set to 330m3/h – an exchange rate of 555/h in the cabinet – and 25600 for the purge tube.
Electrical components inside the Zone 2 areas must comply with IEC/EN 60079-15/1.

The safety related function of the Flow control and Emergency stop has to fulfill the Functional safety standard, EN13849-1 to a Performance level c according to appendix 8, as the unit must be classified as a machine according to dir. 2006/42/EC.

To assure this non-hazardous Zone, the inlet of the ventilation must be taken from a non-hazardous Zone as well, i.e. the surrounding area of the unit must be a non classified area

7.6.5.2 Recovery process
During recovery/recycling the compressor will compress flammable R1234yf, but the mixture will never get into the flammable area of LFL and HFL.

The inside of the compressor can therefore be classified as a non hazardous area, and a normal hermetic compressor can thus be used, when following the appropriate precautions according to IEC/EN 60079-15.

Supply/refill bottle is to be connected like an AC-unit for refilling purposes, and thus treated like the recovery process.

7.6.5.3 Evacuation process
During the evacuation process, flammable gas mixtures could be evacuated through the vacuum pump, but the amount is negligible, therefore the inside of the pump is non-hazardous.
The pump can be installed in 2 different ways:
If the pump is mounted inside the Zone 2 area, thus the motor of the pump must be suitable for Zone 2.
The pump can be installed inside the cabinet, but within the px-Zone, and thus again with an ordinary motor. See appendix 1 Zone Classification.

7.6.5.4 Charging process
In the charging process, the refrigerant in the piping system, will only contain very small amounts of air, (ppm area), and thus be well outside the flammable area of R1234yf. Zone inside components in this process can therefore be considered non hazardous.

7.6.5.5 Test process
In the test process, the risk of getting into the flammable area of LFL and HFL is the same as evaluated for the recovery process. Zone therefore to be classified as non hazardous

7.6.5.6 Vent areas
The purge from the vacuum pump, - the oil-drain and the safety valve, will create flammable mixtures every time they are in operation. But according

to evaluation done by AGRAMKOW the amounts are negligible wherefore they can be purged into the Zone 2.

The vent of the air purge is Zone 1, wherefore it must be connected downstream of the fan. With the correct ventilation capacity and availability, also this vent can be downgraded to non hazardous.
If local requirements demand it, the vent can also be connected to shop ventilation or out of the window via a hose.

7.6.5.7 Fan
The fan must be suitable for Zone 2. The purge from the air purge is Zone 1 at the point of ejection, wherefore the purge point has to be after the fan.

7.6.5.8 Power switch and power supply
The power-sensor and supply are also during operation situated in a non-hazardous Zone using the method px, according to IEC/EN60079-2 using sufficient ventilation with no possible release in the area (shielded from possible releases).

7.6.5.9 Pressure gauges
The pressure gauges are installed in the top section of the unit. The gauges are connected with hoses, which hold a Zone 1 inside. Normally this would create a Zone 2 on the outside of the connections hereto. The solution consists of a protection hose on the outside of all Zone areas of the gauges, which are connected to the ventilated Zone 2 area of the bottom section. Hereby the top section can remain non-hazardous.

7.6.5.10 HMI PCB
The top section is defined to be a non-hazardous Zone due to encapsulation of the hoses for the pressure gauges installed here. Thus no special precautions to be made for the HMI PCB (Human-Machine Interface Printed Circuit Board).

7.6.5.11 Printer
The printer is also installed in the top-section, - same conclusions as with the HMI PCB.

7.6.6 Car service area

7.6.6.1 Service couplers
During the recovery, evacuation processes, the Zone is classified as Zone 2. During the charging and Test-process, the Zone can be classified as non hazardous.

7.6.6.2 Engine compartment
The Zone of the engine compartment follows the definition of the Zone of the couplers.

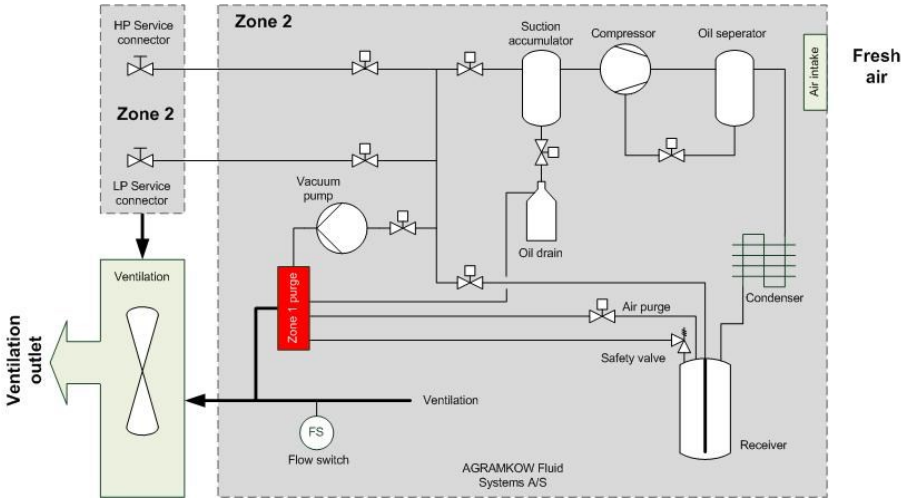
7.6.6.3 Fire safe zone
Outside the Zone 2 area, there is also defined a Fire Safe Zone, where no open fire or hot surfaces are allowed, and where warning signs are to be installed. Area is defined as a 5m radius around the zone 2 area.

7.6.7 Emergency stop

The service unit is equipped with an emergency stop – according to EN60204-1. A combined emergency and power sensor according to IEC60947-3 is used.
A remote emergency stop must also be available to assure a safe stop in case a dangerous situation has evolved in the close vicinity of the unit.
It is the owner's responsibility to install an Overall Emergency Stop/power separator of the power supply to the unit.
This power separator must be placed in a safe distance to the working area.
A normal plug is also accepted as a power separator.

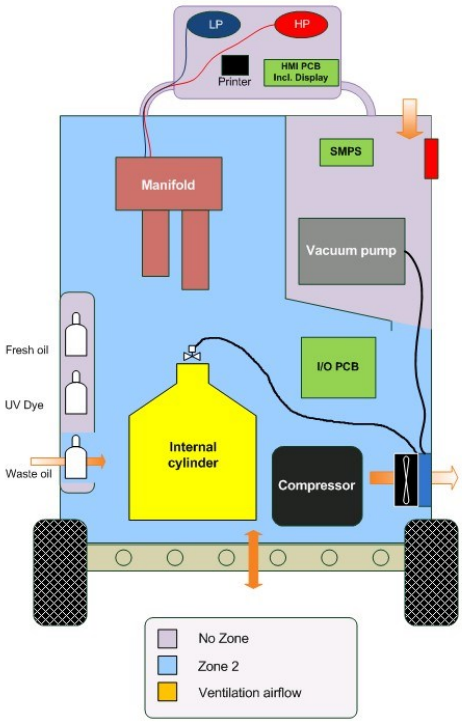
7.6.8 Conclusion

Considering the above mentioned safety precautions in the design of the service system we consider it safe.
This safety, however, requires a mandatory planning of maintenance and control of all safety items in adequate intervals, maintained escape routes etc. acc. to ATEX 1999/92/EU.



Figur 2 PI Diagram for R1234yf Service Unit

Som det ses i Figur 2 er der zone 2 klassificering omkring koblinger samt inden i enheden. Ligeledes ses det at der bliver samlet kølemiddel fra Air purge, sikkerhedsventil, vakuum pumpe samt fra olie flaske. Fra tre af disse fire opsamlingssteder bliver kølemiddel "blæst af" som en naturlig del af processen, og det er derfor vigtigt at opsamle dette kølemiddel og lede det til ventilationen. Ventilationen er i dette tilfælde egnet til at håndtere brændbare kølemidler.

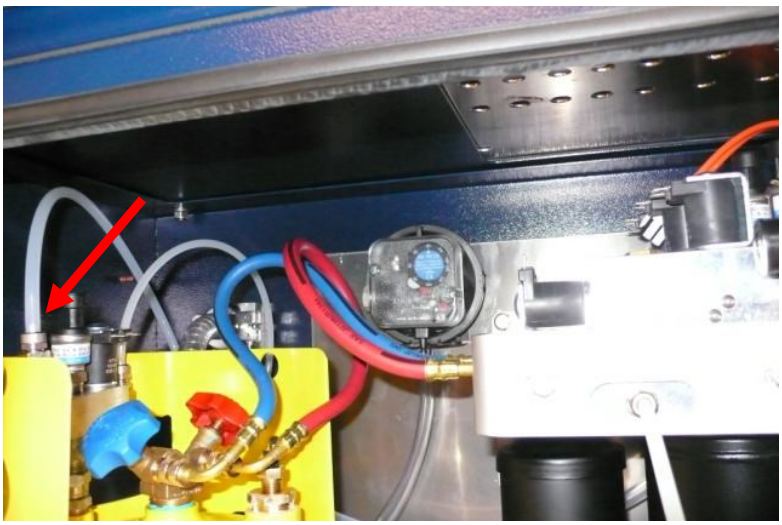


Figur 3 Principskitse på fysisk opbygning af service station

Figur 4 RHS1280 prototype til servicering af MAC med R1234yf kølemiddel

Som beskrevet i sikkerheds-/servicekonceptet (bilag C) er det specielt nødvendigt at opsamle de brændbare gasser fra udledningspunkterne vist i Figur 2. Som eksempel er dette vist i Figur 5 hvor ikke kondenserbare gasser bliver opsamlet og ledt væk til ventilationen.

I dette tilfælde anses den udledte gas at skabe Zone 1 omkring udledningsstedet. Gassen føres derfor til punktet foran ventilatoren (udgangssiden) og ikke indgangssiden da ventilatoren i så fald skulle have været klassificeret til Zone 1.



Figur 5 Slange tilslutning til bortledning af ikke kondenserbare gasser

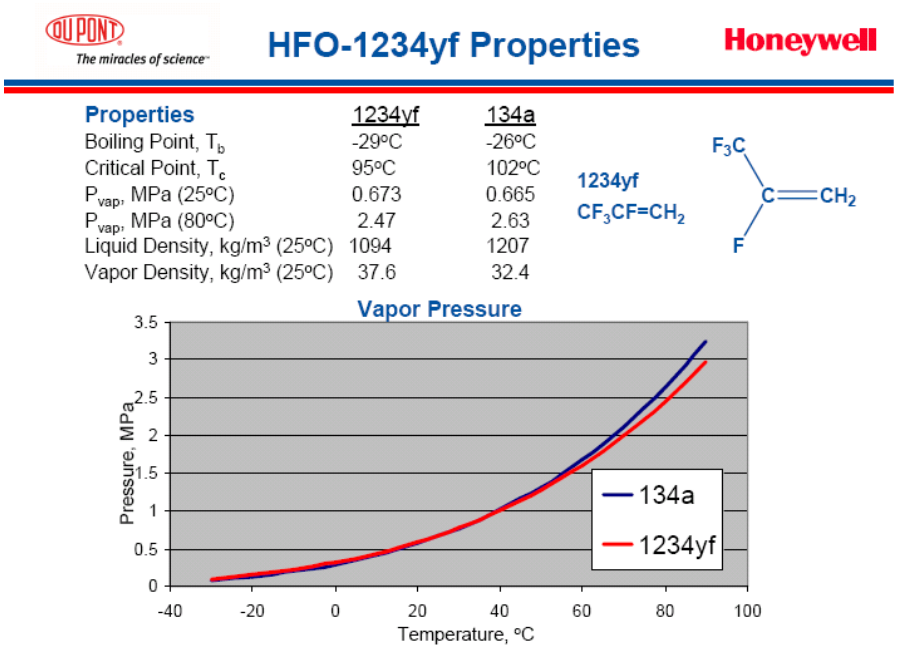
7.7 Produkt specifikationer

Kølemiddel	R1234yf (HFO1234yf)
Cylinder	13,6 kg
Maks kølemiddel kapacitet	10 kg
Sprog support	Tysk og Engelsk
Fyldeslanger	Højtryksslange 3 m rød Lavtryksslange 3 m blå
Service koblinger	R1234yf (prototype) –SAE J639
Genindvinding	>95%*
Vakuum pumpe	16m3
Fyldenøjagtighed	±15 gram*
Fyldemængde	150 gram – 1500 gram
Fyldeteknologi	Vejecelle/vægt
Automatisk olie påfyldning nøjagtighed	±1 gram
Ny olie kapacitet	500 ml
Gammel olie kapacitet	500 ml
Processer	Genindvinding Vakuum Vakuum check Automatisk olie påfyldning For-fyldning Fyldning
Arbejdstemperatur	10 - 50°C
Forsyning	230V/50Hz – 8A
Vægt	175 kg
Ventilation	
Ekstern ventilator	3000m3/time
Spændings forsyning	230V/50Hz – 10A
Ventilations skuffe dimension	800x1200x100 mm

* I henhold til SAE J2843/SAE J2788

7.8 Teknisk beskrivelse af kølemidlets egenskaber

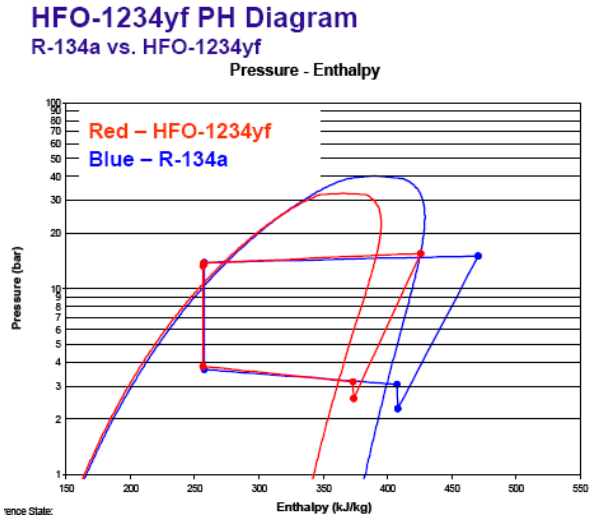
Som udgangspunkt er kølemidlets egenskaber meget tæt på R134a kølemidlet hvilket også betyder at service stationens krav til tryk og temperaturforhold er meget lig det kendte fra R134a. Imidlertid er der en lille forske på tryk versus temperatur hvilket også kan ses i følgende figur.



Figur 6 P-T diagram for R134a versus R1234yf

På diagrammet vist I Figur 6 ses det tydelig hvor lille forskellen mellem R134a og R1234yf er når det gælder tryk versus temperature. Den eksakte tekniske ændring der skal foretages i udstyret er at tabellen for udblæsning af ikke kondenserbare gasser skal tilpasses.

Når det gælder kølemidlets evne til at transportere energi kan det i følgende figur anskuliggøres at R1234yf ikke er så effektivt som R134a til at transportere enerigen i systemet.



Figur 7 Log PH disgram for R134a versus R1234yf

Denne reducerede evne til at transportere energy kræver ikke ummidelbart nogen ændring af serviceudstyrets design og komponenter men imidlertid må det forventes at det i fremtidens biler vil være nødvendigt at indbygge en varmeveksler i kølekredsen.

7.9 Fieldtest R1234yf Service enhed

Service enheden har befundet sig I test hos VW siden september 2009. Enhedens opgave er at service de biler der anvendes i VW's udviklingsafdeling. Dvs enheden servicerer primært nye MACs og er derfor ikke helt repræsentativt for den endelige anvendelsesområde for enheden.

VW, som er et meget aktivt medlem af VDA arbejdsgruppen (bestående primært af VW, Audi, Daimler og BMW), har været medvirkende til at påvirke den endelige krav specifikation af serviceudstyret. Disse krav er med jævne mellemrum blevet videregivet til AGRAMKOW således at det på et tidligt tidspunkt har været muligt at lave nødvendige tilretninger.

Det selvfølgelig klart, at et positivt test resultat er af stor betydning for AGRAMKOW Fluid Systems A/S, da dette automatisk vil give en god reference ind til den gruppe af OEM's, som driver R1234yf udviklingen indenfor MACs.

Field test forløbet har indtil nu fungeret meget godt. Der har naturligvis været en række ønsker om ændringer og forslag til forbedringer men i det store hele har VW været godt tilfreds og anvender enheden i det daglige arbejde.

8 Formidling, Seminarer og konferencer

8.1 Seminarer og konferencer

Der er selvfølgelig en lang række af seminarer og konference som vedrører temaet "R1234yf fremtidens kølemiddel". De fleste af disse tager afsæt i selve teknologien og ydelsen i et R1234yf MAC, hvorfor en del af disse ikke måtte have vores interesse, grundet vores vinkel er påfyldning (processen omkring servicering af R1234yf).

Af de seminarer og konferencer som har været af betydning for AGRAMKOW Fluid Systems A/S vil vi gerne nævne:

1. VDA Alternate Refrigerant Winter Meeting i Østrig
2. KVCA Køle VirksomhedsCenter
3. VDA Arbejdskreiss i Fulda – præsentation af R1234yf service koncept
4. SAE Automotive Alternate Refigerant Systems Symposium
5. Tyske OEM's – præsentation af R1234yf service koncept
6. EAAC 2008 og EAAC 2010 - Frankfurt

Agramkow har i pkt 2, 3 og 5 haft mulighed for at præsentere vores teknologiske landvindinger.
Herudover er det så blevet til en lang række foredrag hos vores andre kunder vedrørende alle de temaer der kommer til at gøre sig gældende ved indførelse af R1234yf.

Bilag

	Budgettal			Regnskabstal		
Personaleudgifter	Timer	Sats	Kroner	Timer	Sats	Kroner
Ledelse	700	kr 700	kr 490.000	700	kr 700	kr 490.000
Projektleder	490	kr 500	kr 245.000	490	kr 500	kr 245.000
Nøglemedarbejdere	4.500	kr 350	kr 1.575.000	4.500	kr 350	kr 1.575.000
Øvrige medarbejdere	250	kr 300	kr 75.000	250	kr 300	kr 75.000
Lønomkostninger i alt:			kr 2.385.000			kr 2.385.000
Udarbejdelse af rapport			kr 20.000			kr 20.000
Interne omkostninger i alt			kr 2.405.000			kr 2.405.000
Eksterne omkostninger						
Underleverandører			kr 250.000			kr 250.000
Uddannelse			kr 50.000			kr 49.527
Leje af bygning og udstyr			kr 50.000			kr 50.000
Rejser			kr 90.000			kr 90.000
Revision			kr 40.000			kr 20.000
Testudstyr og prototyper			kr 610.000			kr 610.000
Eksterne omkostninger i alt			kr 1.090.000			kr 1.069.527
Omkostninger i alt			**kr 3.495.000**			**kr 3.474.527**
Tilskud	**Maks tilskud 25%**		**kr 873.750**	**Maks tilskud 25%**		**kr 868.632**

Dato og underskrift tilskudsmodtager:

Dato:

Dato:

Christian Cordsen
Nielsen
Adm. Direktør

Leif Thyssen
BU2 Manager

Bilag B: Marketing materiale

AGRAMKOW

RHS 1280

R1234yf charging for service, R&D and pilot production

RHS 1280

R1234yf charging for service, R&D and pilot production

Now the automotive industry can harness R1234yf for mobile air-conditioners safely and efficiently. Using the new RHS1280 from AGRAMKOW

Connect, program and walk away. The AGRAMKOW RHS1280 A/C refrigerant handling machine performs an automatic recover, recycle and recharge procedure by the A/C SAE J2843 compliant technology developed by AGRAMKOW.

Fully automatic processes

The RHS1280 intuitive user interface gives operators valuable information about the process and condition of the equipment. All limits are easily programmable to assure perfect process performance. The equipment is controlled by AGRAMKOW's HMI controller fulfilling EN 60204-1 standards.

The process can run automatically or step vice, and three programs are available: Recover/recycle – Evacuation – Charging.

Superior evacuation

The RHS1280 features an 16m³ vacuum pump and an electronic vacuum gauge, enabling the evacuation and vacuum control to run automatically, without operator influence. This assures a perfect evacuation, which is critical for MAC applications that must avoid exposing the circuit to humidity.

Reliability and safety

AGRAMKOW has conducted extensive studies to develop equipment managing R1234yf for automotive applications. One of our priorities has been to develop a cost effective way to make this possible, without compromising safety or performance.

AGRAMKOW work closely with industry partners, major automotive manufacturers' and TÜV (Technischer Überwachungs-verein - Technical Inspection Association) to assure the performance, reliability and safety of our R1234yf solutions.

The RHS1280 is designed according to AGRAMKOW's TÜV approved concept. This guarantees full ATEX compliance and ensures safe and reliable operation. The RHS1280 together with the optional ventilation system provides a complete solution for the workshop.

RHS1280 represents AGRAMKOW's commitment to the future... to create and enhance products that help our customers improve their environmental and operating performance.

AGRAMKOW

AGRAMKOW Fluid Systems A/S
Augustenborg Landevej 19 · DK-6400 Sønderborg
Tel: +45 74 42 36 36 · Fax: +45 74 43 36 46

www.agramkow.com

123-410001A-00

Technical specifications

Refrigerant	R1234yf (HFO-1234yf)
Cylinder	13.6 kg
Max capacity	10 kg
Language support	German/English
Charging hose	HP 3 m Red/LP 3 m Blue
Couplers	R134a**
Recovery performance	95%*
Vacuum pump	16 m³ with Oil mist filter
Charging accuracy	±15 gram*
Charging amount	150 gram - 1500 gram
Charging technology	Load cell/Weight
Automatic oil charge accuracy	± 1 gram
Fresh oil capacity	500 ml
Waste oil capacity	500ml
Processes	Recovery Vacuum Vacuum check Automatic Oil Charge Pre-charge Charge
Operating temperature	10 - 50 °C
Voltage supply	230V/50Hz - 8A
Dimensions (WxLxH)	850 x 720 x 1400 mm
Weight	~175 kg

Ventilation

External ventilator	3000 m³/hour
Voltage supply	230V/50Hz - 10A
Tray dimensions (WxLxH)	800 x 1200 x 100 mm

Part numbers

RHS1280 Service Unit	123-000200A
External ventilator for RHS1280	123-000201A
Ventilation tray for RHS1280	123-000202A

* According to J2843
** Standard for R1234yf not finalized

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HFO1234yf Safety-/Service Concept

HFO-1234yf
Technical facts

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Disclaimer

2

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Agenda

- References
- Classification
- Regulations
- Process & working area
- Safety issues

3

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Background

- AGRAMKOW is the worldwide leading manufacturer of filling equipment in the business segments Appliance, Automotive and Automotive after marked
- AGRAMKOW is in the flammable business since 1992 with the first TÛV approved production equipment in the world for R600a
- AGRAMKOW is familiarly with EX issues by automotive production lines due to supply and installation of gasoline fuelling equipment and Wind Screen Mixture



4

AGRAMKOW

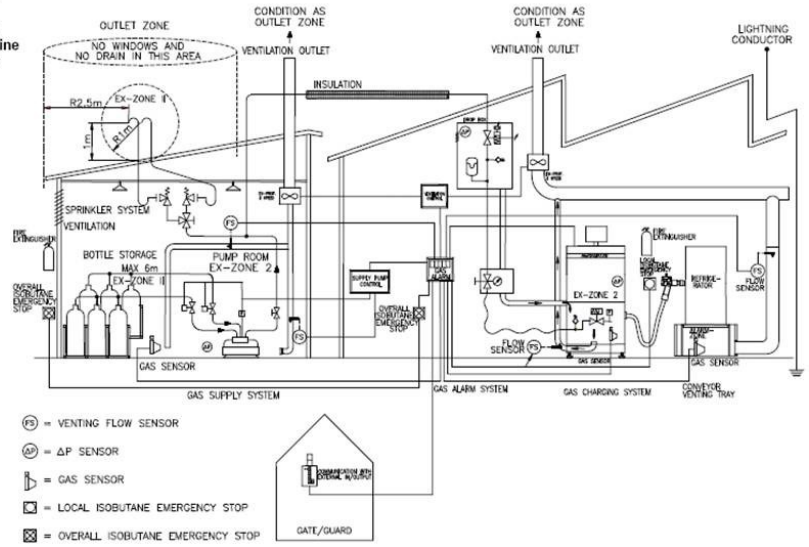
1992 world first
"TÜV" design

2008
AGRAMKOW design

AGRAMKOW

Specifications
Safety system SAFE-IR
Page 12 of 37

System layout bottle supply in pump room & Production line With drop box



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HFO1234yf Service Concept

Classification

Flammability

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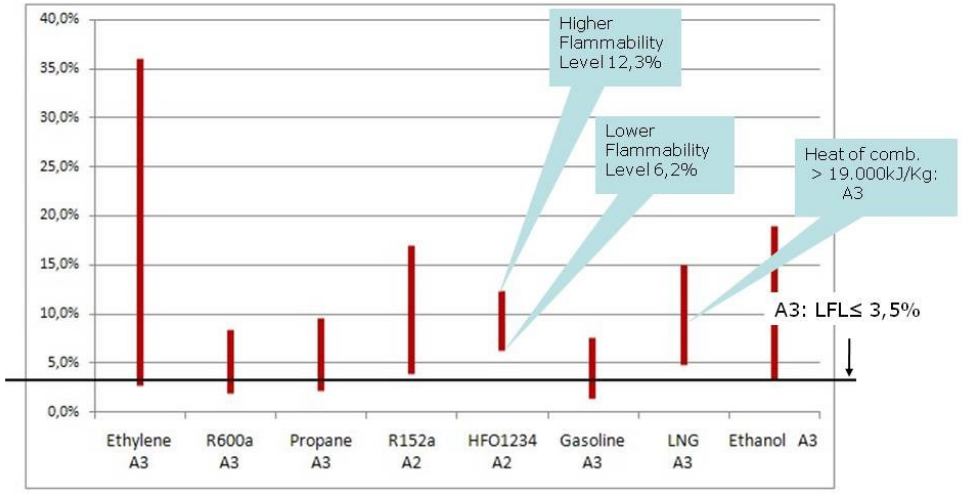
Safety classification EN378-1:2008



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EN378-1 Safety groups

Increasing flammability ↑	Safety group	
Higher flammability	A3	B3
Lower flammability	A2	B2
No flame propagation	A1	B1
	Lower toxicity	Higher toxicity

→ Increasing toxicity

For the purpose of this standard a simplified grouping is made as follows:

L1 = A1;
L2 = A2, B1, B2;
L3 = A3, B3.

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Flammability

Safety classification EN378-1:2008

Class 2 refrigerants:
- exhibits flame propagation when tested at 60°C (@ 101,3kPa)
- has a LFL ≥ 3,5 % v/v
- has a heat of combustion < 19.000 kJ/Kg

Class 3 refrigerants:
- exhibits flame propagation when tested at 60°C (@101,3kPa)
- has a LFL ≤ 3,5 % v/v; or has a heat of combustion ≥ 19.000 kJ/Kg

-HFO1234 does feed a flame
- LFL ≥ 3,5 % v/v
- heat of combustion < 19.000 kJ/Kg (9.500 source Dupont) (11.800 source ARKEMA)

HFO1234yf will be classified a Class A2* refrigerant acc. to EN378-1 AnnexF

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* A = non toxic

AGRAMKOW

ARKEMA view

HFO 1234yf : Stakes for the Automotive Industry

✓A safe and dedicated distribution network is key for the Success of a worldwide implementation of HFO 1234yf

✓ATEX Level 2 reglementation needs to be applied at distribution NetWork.

✓Importance of local distribution net work in respect of security and proximity of OEM and After market/ Servicing.

✓ARKEMA is proposing a dedicated Tech support at OEM , Distributors and after market Net Works .

✓ARKEMA HFO 1234yf distribution is backed to a strong local distributors Network and highest expertise in logistics .

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ARKEMA The world is our inspiration

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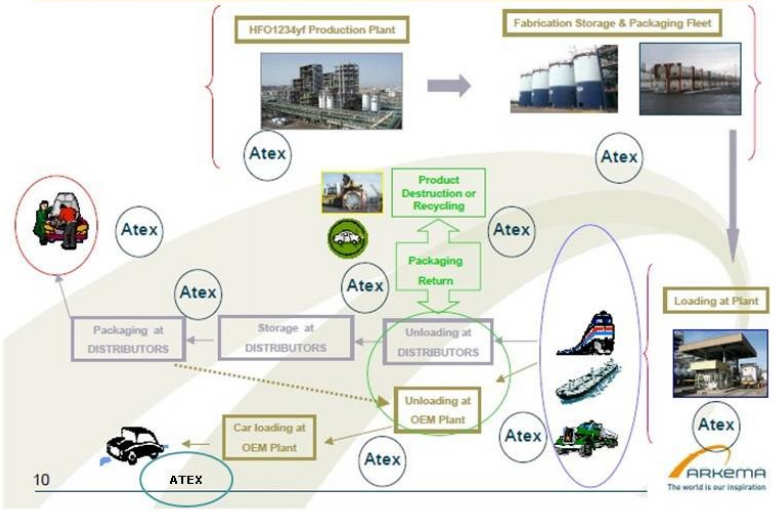
AGRAMKOW

HFO 1234yf Typical Supply Chain

Forane



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MSDS of HFO-1234yf

SECTION 5. FIRE-FIGHTING MEASURES

Flash point	:	not applicable
Ignition temperature	:	405 °C (761 °F)
Lower explosion limit	:	6.2 %(V)
Upper explosion limit	:	12.3 %(V)
Flammability (solid, gas)	:	Extremely flammable gas. Flammability (gases)

HFO-1234yf is heaver than air gas

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ATEX or not?

ATEX does not distinguish between the degree of flammability: it applies for Class 2 as well as Class 3 gasses/refrigerants.

In other terms: ATEX applies for HFO1234yf!

Already applied ATEX fluids/gases:
LNG
Gasoline
Wind screen fluids

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HFO1234yf Service Concept

Regulations

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Responsibility

- Customer
  - ATEX directive 1999/92/EU regarding the working area
- AGRAMKOW
  - ATEX directive 94/9/EU regarding the equipment

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Equipment regulations

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	Standards
	ATEX
Classification of refrigerants	EN378-1
Classification of vapours and gasses	IEC 60079-12
Safety and occupancy	EN378-3
Ex-n protection types Zone 2	EN/IEC 60079-15
Ex-d pressure-tight protection	EN/IEC 60079-1
Ex-p pressure encapsulation	EN/IEC 60079-2
Ex-e increased safety	EN/IEC 60079-7
Zone classification	EN/IEC 60079-10
Electrical code	EN 60204-1
Functional Safety (29.dec 2009)	EN ISO 13849-1
Non electrical equipment	EN 13463-1

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EN 13849-1 (29.dec 2009)

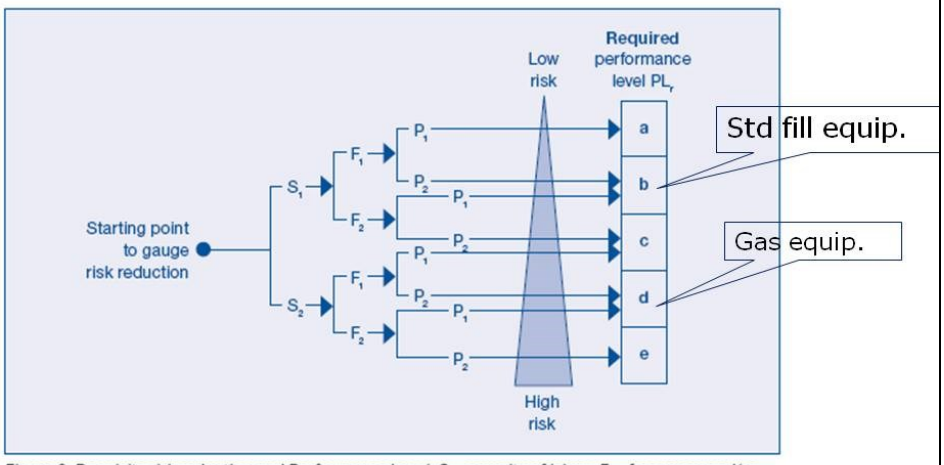

Figure 3: Requisite risk reduction and Performance Level: S = severity of injury; F = frequency and/or duration of exposure to hazard; P = potential to reduce the hazard.

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Equipment regulations

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Standard Title	Standards (under revision)
HFC-152a and HFO-1234yf Refrigerant Recovery/Recycle/Recharging Equipment for Mobile Air Conditioning Systems	SAE J2843
HFO-1234yf Refrigerant Purity and Container Requirements for Refrigerant used in Mobile Air Conditioning Systems	SAE J2844
Technician Certification for Servicing and Refrigerant Containment of A/C Systems	SAE J2845
HFC-152a and HFO-1234yf Refrigerant Recovery Only Equipment for Mobile Air Conditioning Systems	SAE J2851
HFO-1234yf Service Standards for Mobile Air Conditioning Systems	SAE J2887
Service Hose, Fittings and Couplers for Mobile Refrigerant Systems and Service Equipment	SAE J2888

9

Classification, labeling and packaging of chemical substances and mixtures

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Dir. 67/548/EU through June 2015

Article 1
1. The purpose of this Directive is to approximate the laws, regulations and administrative provisions of the Member States on:
- classification,
- packaging, and
- labelling

of dangerous substances which are placed on the market in the Member States of the Community.

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Classification, labelling and packaging of chemical substances and mixtures

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Dir. 67/548/EU through June 2015

Article 2.2
The following substances and preparations are "dangerous" within the meaning of this Directive:

(a) explosive:
substances and preparations which may explode under the effect of flame or which are more sensitive to shocks or friction than dinitrobenzene;

(b) oxidising:
substances and preparations which give rise to highly exothermic reaction when in contact with other substances, particularly flammable substances;

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Classification and labelling

AGRAMKOW

Dir. 67/548/EU through June 2015

Article 2.2.

(c) easily flammable: - substances and preparations which may become hot and finally catch fire in contact with air at ambient temperature without any application of energy, or
- solid substances and preparations which may readily catch fire after brief contact with a source of ignition and which continue to burn or to be consumed after removal of the source of ignition, or
- liquid substances and preparations having a flash point below 21°C, or
- gaseous substances and preparations which are flammable in air at normal pressure, or
- substances and preparations which, in contact with water or damp air, evolve highly flammable gases in dangerous quantities;

(d) flammable:
liquid substances and preparations having a flash point between 21°C and 55°C;

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Flammable gasses

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REGULATION (EC) No 1272/2008 - from Dec.2010

Repealing Dir. 67/548/ECC and 1999/45/EC

2.2.2 Classification criteria

2.2.2.1. A flammable gas shall be classified in this class in accordance with Table 2.2.1:

Table 2.2.1
Criteria for flammable gases

Category	Criteria
1	Gases, which at 20°C and a standard pressure of 101,3 kPa: (a) are ignitable when in a mixture of 13 % or less by volume in air; or (b) have a flammable range with air of at least 12 percentage points regardless of the lower flammable limit.
2	Gases, other than those of Category 1, which, at 20°C and a standard pressure of 101,3 kPa, have a flammable range while mixed in air.

HFO1234 with af LFL of 6,2-6,5% and HFL of 12,3% applies to Cat. 1(a)

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Flammable gasses

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REGULATION (EC) No 1272/2008 - from Dec.2010

Table 2.2.2
Label elements for flammable gases

Classification	Category 1	Category 2
GHS Pictogram		No pictogram
SignalWord	Danger	Warning
Hazard Statement	H220: Extremely flammable gas	H221: Flammable gas

R12 acc.to old dir. 67/548/EC

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Flammable liquids

AGRAMKOW

REGULATION (EC) No 1272/2008 - from Dec.2010

2.6.2 Classification criteria

2.6.2.1. A flammable liquid shall be classified in one of the three categories for this class in accordance with table 2.6.1:

Table 2.6.1
Criteria for flammable liquids

Category	Criteria
1	Flash point < 23°C and initial boiling point ≤ 35°C
2	Flash point < 23°C and initial boiling point > 35°C
3	Flash point ≥ 23° C and ≤ 60° C (1)

(1) For the purpose of this Regulation gas oils, diesel and light heating oils having a flash point between ≥ 55°C and ≤ 75°C may be regarded as Category 3.

Wind screen fluids: approx >23ºC (50/50%) Gasoline: <-40ºC Diesel: >62ºC

The flash point of a flammable liquid is the lowest temperature at which there can be enough flammable vapour to ignite, when an ignition source is applied.

A slightly higher temperature, the fire point, is defined as the temperature at which the vapour continues to burn after being ignited

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Flammable liquids

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REGULATION (EC) No 1272/2008

Table 2.2.2
Label elements for flammable liquids

Classification	Category 1	Category 2	Category 3
GHS Pictogram			
SignalWord	Danger	Danger	Warning
Hazard Statement	H224: Extremely flammable liquid and Vapour	H225: Highly flammable liquid and Vapour	H226: Flammable liquid and vapour

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Flammable liquids

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danish proclamation no. 161 of 26. april 1985

1.1.3 Flammable liquid with a flame point of max. 100° C.

Class I: flame point below 21° C.

Class II: flame point between 21 and 55° C (both values incl.).

Class III flame point above 55° C.

All classes are subdivided into a subclass 1 for liquids , which are not soluble in water at all conditions , and subclass 2 for liquids which are soluble at all conditions.

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European ATEX marking

Minimum Ignition Energy (MIE):

The minimum energy required from a capacitive spark discharge to ignite the most easily ignitable mixture of a gas or vapour. (Used as criteria in EU).
This value is not used to classify, if the gas is flammable or not – but to defining the limits when using the different types of protections, (intrinsic safety , ia,b,c or power limiting measures, nL).

ATEX applies for Class 3 gasses as well as Class 2, but the limits of the protections types as intrinsic safety (ia, ib, ib), non-incendive or power limitation, (nL), depend on the class of the gas.

HFO1234yf has an ignition energy higher than 5000 µJ, which put it into gas group IIA. See next slide.

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European ATEX marking

Group		inimum Ignition Energy (MIE) [µJ]
I		280
IIA	Ammonia, Ethane, Propane, n-Butane, Fuel in gen., Aircraft fuel, Fuel oil	> 180
IIB	Ethylene, Ethylene oxide, Ethylene glycol, Ethyl ether	60……180
IIC	Hydrogen, Acetylene	< 60

With more than 5000 µJ HFO1234yf will practically not be ignited by a typical static discharge.

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European ATEX marking

CE 0344 Ex II (1)G [Ex ia] IIC T6

Conditions in potentially explosive areas ATEX 94/9/EC

Flammable substances	Temporary behavior of flammable substances in the Ex area	Categorization of the potentially explosive areas	Required labeling of the used items in accordance with CENELEC		IEC 60079-0 (starting from Edition 5.0)
			Device group	Category	Equipm. protect. level (EPL)
Gas Fog Liquid	Continuous, long periods, frequent	Zone 0	II	1G, (1)G	Ga
	Occasional	Zone 1	II	2G, (2)G	Gb
	Normally not, only for a short period	Zone 2	II	3G, (3)G	Gc
Dust	Continuous, long periods, frequent	Zone 20	II III (IEC 60079-0 starting from Edition 5.0)	1D, (1)D	Da
	Occasional	Zone 21	II III (IEC 60079-0 starting from Edition 5.0)	2D, (2)D	Db
	Normally not, only for a short period	Zone 22	II III (IEC 60079-0 starting from Edition 5.0)	3D, (3)D	Dc
Methane Coal dust	Constantly	Coal mining	I	M1	Ma
Methane Coal dust	Frequent	Coal mining	I	M2	Mb

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European ATEX marking

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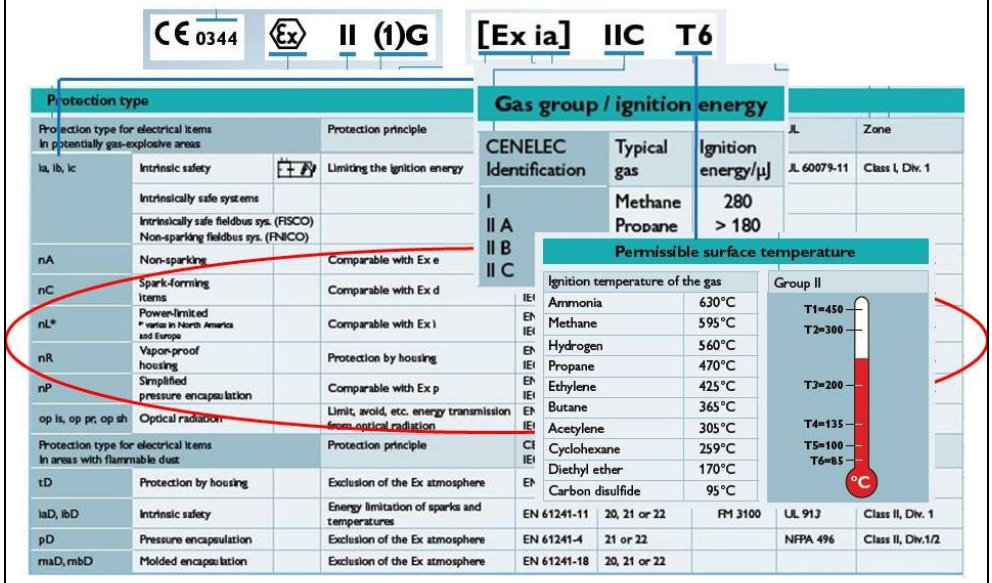

Waste regulations

AGRAMKOW

According to the F-Gas regulation, EU 842/2006, it is not permissible to purge a F-Gas. Although HFO-1234yf has a low GWP, and is not listed in the regulation yet, it will probably at some stage be implemented in Annex 1 of the regulation.

Also local waste regulation will not accept the purge of a chemical substance.

Consequently recovery will also be mandatory for HFO-1234yf Service equipment.

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Equipment regulations

AGRAMKOW

In the past EN 60335-1 has been used for the electrical code for recovery and recycling equipment in Europe.

EN 60335-1 specifically states, NOT to apply for equipment where explosive atmosphere can be present (gas, vapour or dust).

Therefore only the machine directive 98/37/EU, (2006/42/EU from 29.dec.2009) and thus EN 60204-1 apply as the electrical code.

This also means, that the code for functional safety of machinery, EN 13849-1 will apply after 29.Dec.2009.

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Ventilation acc.to IEC 60079-10

AGRAMKOW

In IEC 60079-10-1995 a Zone 1 or 2 with low ventilation, can be lowered to a non-classified Zone, if the ventilation is changed to a medium or high degree. Ventilation therefore often becomes a technical feasible solution.

Ventilation is furthermore divided into 3 grades of availability: Bad (Poor), Acceptable (Fair) and Good. See hereto Table B.1 of IEC 60079-10.

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Zone area classification acc. to IEC 60079-10

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Ventilation Degree:

The ventilation Degree must be calculated, and depend on the following factors:

- the type of gas (lower explosion limit, LFL)
- grade of release (continuous, primary or secondary)
- release rate (amount and speed - grams/sec)
- number of air changes

Ventilation is therefore depending on the size of the area to be ventilated, and must therefore be calculated in each installation case, if ventilation is not limited to the equipment.

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Zone area classification acc. to IEC 60079-10

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Ventilation Availability:

- Good: ventilation is present virtually continuously;
- Acceptable: ventilation is expected to be present during normal operation. Discontinuities are permitted provided they occur infrequent and for short periods;
- Bad: ventilation which does to meet the standard of acceptable and good, but discontinuities are not expected to occur for long periods.

To hold the definition of Good ventilation will require a back-up system if ventilation fails – or provisions for preventing the release of flammable material when the ventilation has failed (for example by automatically closing down the process).

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Zone area classification acc. to IEC 60079-10 – Medium ventilation

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Example No. 4

Control valve, installed in a closed process pipework system conveying flammable gas:

Principal factors which influence the type and extent of zones

Plant and process

Ventilation
- Type ..... Natural
- Degree ..... Medium
- Availability ..... Good

Source of release	Grade of release
Valve shaft seal	HFO-1234yf
Gas density	Greater than air

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Zone area classification acc. to IEC 60079-10 – Medium ventilation

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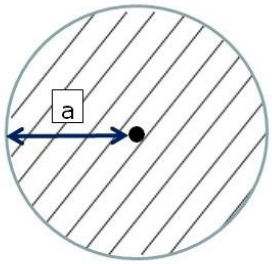

Ground level

- Source of release (valve)

Zone 2 IEC 1245/02

Taking into account relevant parameters the following is the typical value which will be obtained for this example:

a = 1 m in all directions from source of release.

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Ventilation acc.to IEC 60079-10

	Ventilation						
	Ventilation Degree						
	High (VH)			Medium (VM)			Low(VL)
	Availability						
	Good	Acceptable	Poor	Good	Acceptable	Poor	Good, acceptable or poor
Continous, Frequent or long periods	(Zone 0 NE) Non hazardous [a]	(Zone 0 NE) Zone 2 [a]	(Zone 0 NE) Zone 1 [a]	Zone 0	Zone 0 + Zone 2	Zone 0 + Zone 1	Zone 0
Periodically, ocasionally at normal operation.	(Zone 1 NE) Non hazardous [a]	(Zone 1 NE) Zone 2 [a]	(Zone 1 NE) Zone 2 [a]	Zone 1	Zone 1 + Zone 2	Zone 1 + Zone 2	Zone 1 or Zone 0 [c]
Not exp. at normal op. If: only shortly	(Zone 2 NE) Non hazardous [a]	(Zone 2 NE) Non-hazardous [a]	Zone 2	Zone 2	Zone 2	Zone 2	Zone 1 and even Zone 0 [c]

NOTE: "+" signifies "surrounded by"

[a] Zone 0 NE, 1 NE or 2 NE indicates a theoretical zone which would be of negligible exstent under normal conditions.

[b] The Zone 2 area created by a secondary grade of release may exceed that attributable to a primary or continuous grade of release; in this case, the greater distance should be taken.

[c] Will be Zone 0 if the ventilation is so weak and the release is such that in practice an explosive gas atmosphere exist virtually continously (i.e. approaching a "no ventilation " condition).

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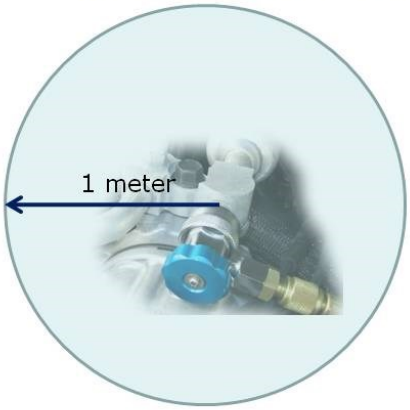
Zone area classification acc. to IEC 60079-10 Ventilation



Zone 2

Ground level

Taking into account relevant parameters, the following is the typical value

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Assessment of Service unit

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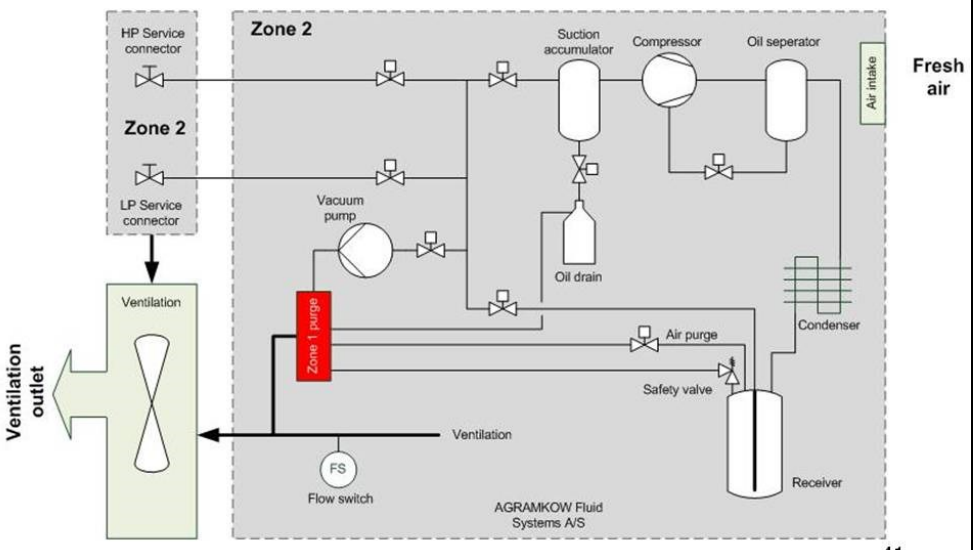

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Assessment of Service unit

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Inside receiver:

- Air purge today, uses approx. 0,5bar air pressure, above the partial pressure of the refrigerant, to stay below the requested purity level.
- Absolute pressure inside receiver will be dependent of the ambient temperature, and whether or not the unit is at the beginning or the end of the recycling process. Pressure will vary from approx. 4 to 15bar (with R134a pressures as ref.).
- With no change, the HFO1234 pct. in the receiver will therefore vary from:
  - 4 bar: 4 / (4+0,5) = 89%
  - 15bar: 15 / (15+0,5) = 97%

  So the vapour mixture in the top of the receiver, will at all times be far away from the ignitable area of HFL.

Zone inside of the receiver is assessed as Zone 1.

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Assessment of Service unit

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Inside cabinet:

- If threaded or compressed fittings are being used, there will be a possibility to get leakages. Consequently, the surrounding of the components must be considered as Zone 2.
  If ventilation degree is designed to ventilation High, the Zone can be non-classified.
  When system is in stand-by, ie. the fan will be off, the Zone becomes Zone 2, if all electrical items in the mechanical cabinet is off, the concept of Zone 2 can be met.

Inside system/piping:

- When handling and recycling, it is inevitable to have air mixed into the refrigerant. But concentration can be shown, to stay out of LFL-HFL area. Zone can therefore be assessed to Zone 2.

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Assessment of Service unit

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Oil drain:

- The oil will have diluted refrigerant , and refrigerant will also escape during the drain. This will be a standard procedure at each service.

Safety valve vent:

- Also the vent here from must be defined as the air purge – although the frequency can be assumed to be a minimum. When purging, the amount and time will be considerable.

All vent-Zones must therefore be defined as Zone 1.

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Assessment of Service unit

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Quick connectors:

- At the quick-connectors, there will always escape small amounts of gas at each disconnection, and even having aut.closing valves in both parts, there will be a potential risk of having leakages at this point.
- According to EN60079-10, the Zone is defined as 1m sphere around the connection point.

Zone at quick-connectors therefore becomes Zone 2.

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Assessment of Service unit

AGRAMKOW

Air purge:

- Although the intention is to purge air only – the mixture which is purged, in state of the art, is dependent only of the partial pressures of the components. Ie. the refrigerant part will be 89 – 97%. This being mixed with the air from the surrounding, will definitely at some stage get into the flammable area.

Vacuum pump vent:

- The vapour pumped by the vacuum pump will at most times be 100% HFO-1234yf, but again when venting it to the surroundings, it will definitely at some point become a flammable mixture, which will happen at each service.

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HFO1234yf Service Concept

The process & work area

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DUPONT The miracles of science

Handling

Honeywell

HFO-1234yf Will Be Handled Similar to R-134a

- Distribution of HFO-1234yf from manufacturer to auto OEM plants and after sales service markets will be similar to R-134a
- Minor changes to plant charging equipment and procedures
- HFO-1234yf can be recovered, recycled and reused on site at service shops
- HFO-1234yf leaks can be detected with same equipment as R-134a
- Unique fittings will be used ensure no cross contamination with R-134a

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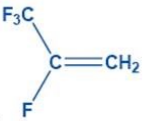
DUPONT The miracles of science

HFO-1234yf Properties

Honeywell

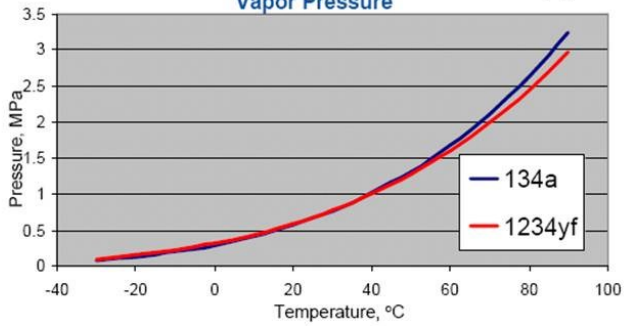
Properties	1234yf	134a
Boiling Point, T_b	-29ºC	-26ºC
Critical Point, T_c	95ºC	102ºC
P_{vap}, MPa (25ºC)	0.673	0.665
P_{vap}, MPa (80ºC)	2.47	2.63
Liquid Density, kg/m³ (25ºC)	1094	1207
Vapor Density, kg/m³ (25ºC)	37.6	32.4

1234yf
$CF_3CF=CH_2$



R134a
CH_2FCF_3

Vapor Pressure



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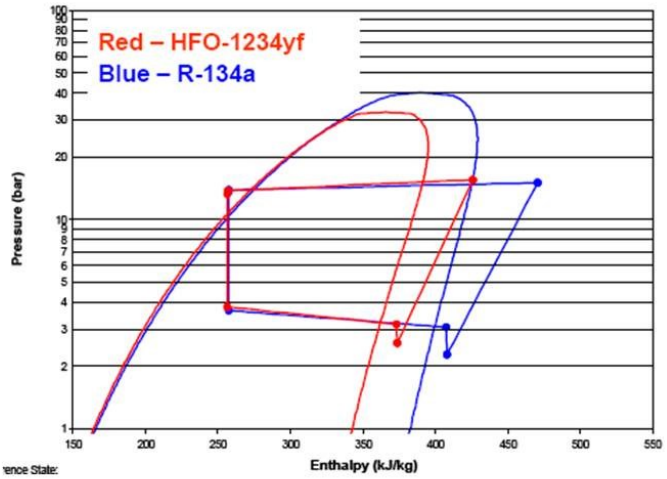
HFO-1234yf PH Diagram

R-134a vs. HFO-1234yf

Pressure - Enthalpy



HFO-1234yf Experimental Data Relative to R-134a

COP = 101%

Capacity = 100%

Vol. Disp = 100%

Massflow = 120%

Charge = 95%

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Zone classification of working area general

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Supply bottle:

-The supply bottle must either be integrated in the Zone 2 compartment of the service station, or be handles as an a/c-service. Otherwise the cone of 1m will be exposed to the surroundings, and the entire space where the station is operated, will become Zone 2.

- The internal amount of the service unit can be max. 10kg. Acc.to EN378-1 Table C.1 for A2 refrigerants for human occupied spaces.

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Practical Zone at Car Alternative 1

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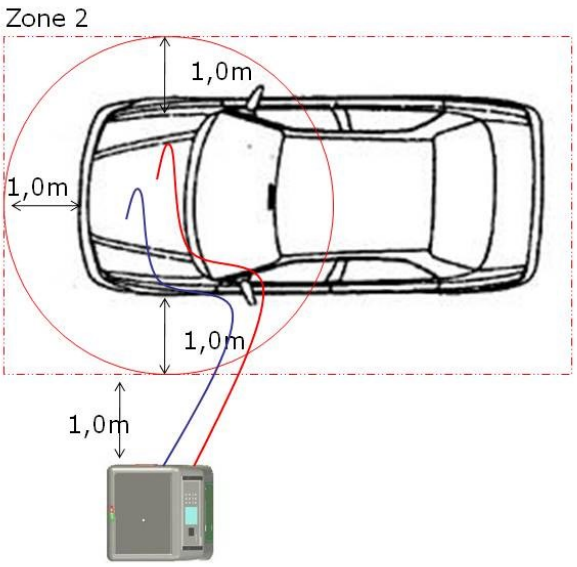

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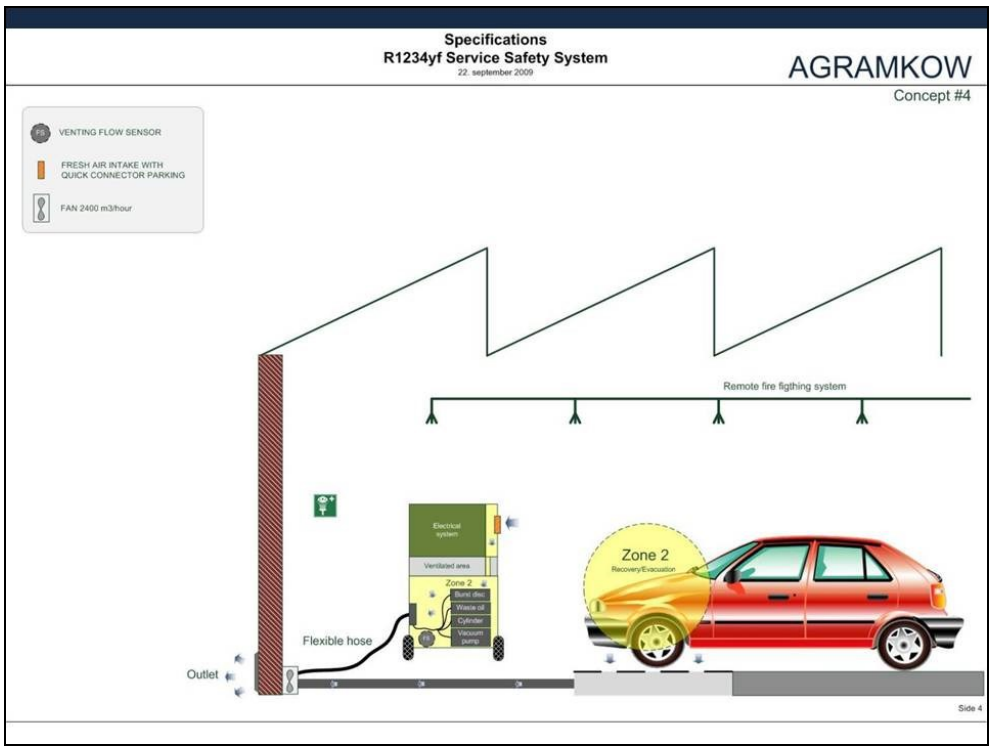
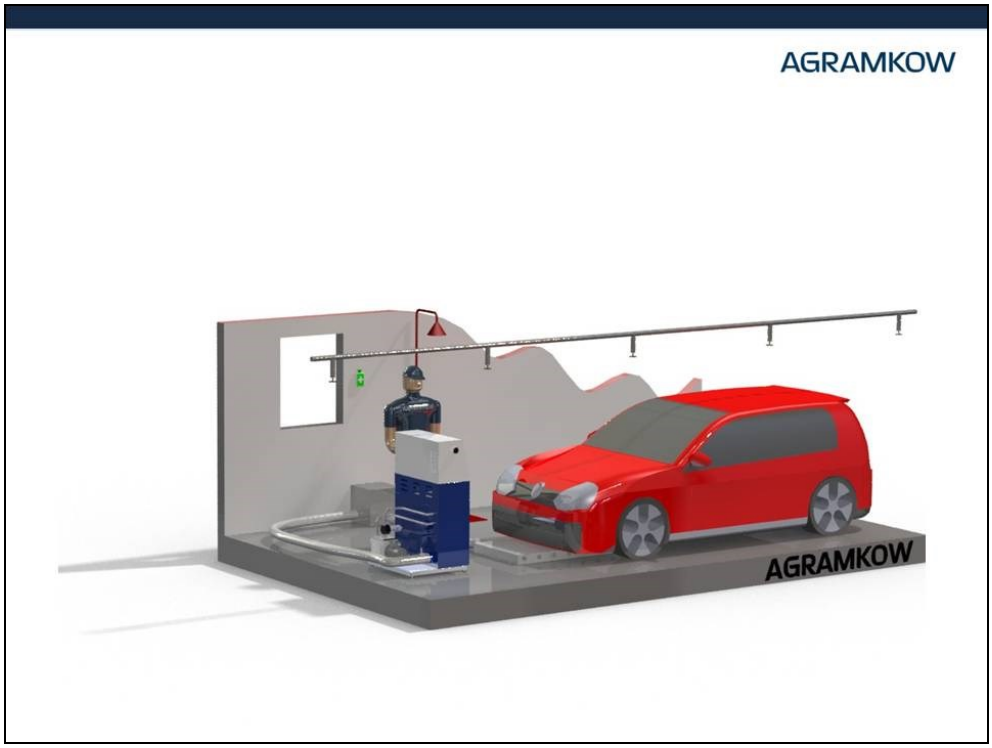

Specifications
R1234yf Service Safety System
22. september 2009
AGRAMKOW
Concept #4
VENTING FLOW SENSOR
FRESH AIR INTAKE WITH QUICK CONNECTOR PARKING
FAN 2400 m3/hour
Remote fire figthing system
Electrical system
Ventilated area
Zone 2
Burn disc
Waste oil
Cylinder
Vacuum pump
Flexible hose
Outlet
Zone 2
Recovery/Evacuation
Side 4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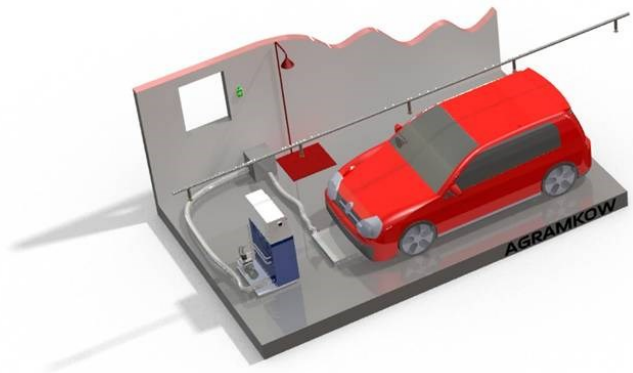

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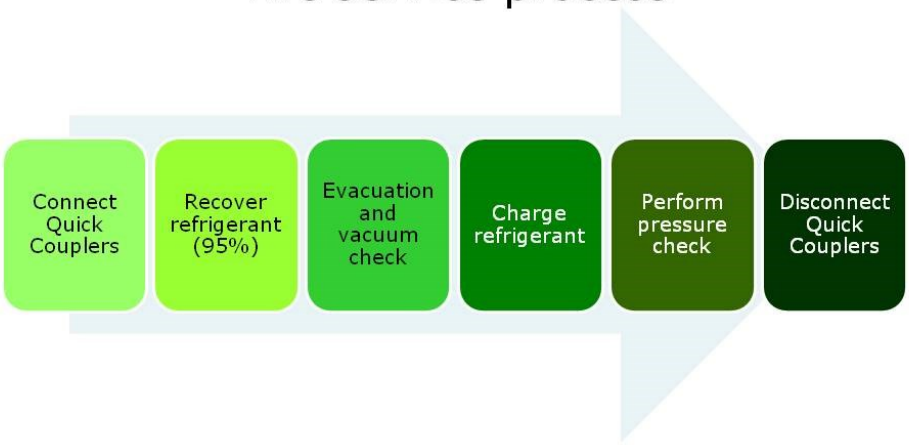
The service process



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HFO1234yf Service Concept

The safety issues

Facts from MSDS

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Material Safety Data Sheet — Honeywell

2,3,3,3-Tetrafluoroprop-1-ene, HFO-1234yf

Version 1 | Revision Date 05/16/2008 | Print Date 05/16/2008

SECTION 2. HAZARDS IDENTIFICATION

Emergency Overview

Form	:	gaseous
Color	:	clear
Odor	:	slight
Hazard Summary	:	Warning! Container under pressure. Flammable gas. Gas reduces oxygen available for breathing. Causes asphyxiation in high concentrations. The victim will not realize that he/she is suffocating. Inhalation may cause central nervous system effects. May cause drowsiness and dizziness. May cause skin irritation. May cause eye irritation. May cause respiratory tract irritation. Do not breathe vapour. Avoid contact with skin, eyes and clothing. At higher temperatures, (>250 C), decomposition products may include hydrofluoric acid (HF) and carbonyl halides. The ACGIH Threshold Limit Values (2007) for Hydrogen Fluoride are TLV-TWA 0.5 ppm and Ceiling Exposure Limit 2 ppm.

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Facts from MSDS

AGRAMKOW

Material Safety Data Sheet — Honeywell

2,3,3,3-Tetrafluoroprop-1-ene, HFO-1234yf

Version 1 | Revision Date 05/16/2008 | Print Date 05/16/2008

SECTION 5. FIRE-FIGHTING MEASURES

Suitable extinguishing media	:	In case of fire, allow gas to burn if flow cannot be shut off immediately. Apply water from a safe distance to cool container and protect surrounding area. Use water spray, alcohol-resistant foam, dry chemical or CO2
Specific hazards during fire fighting	:	Flammable gas. Contents under pressure. Vapours are heavier than air and can cause suffocation by reducing oxygen available for breathing. Vapors may travel to areas away from work site before igniting/flashing back to vapor source. Fire or intense heat may cause violent rupture of packages. Cool closed containers exposed to fire with water spray. Do not allow run-off from fire fighting to enter drains or water courses. In case of fire hazardous decomposition products may be produced such as: Hydrogen fluoride, Carbon monoxide, Carbonyl halides, Carbon dioxide (CO2)
Special protective equipment for fire-fighters	:	In the event of fire and/or explosion do not breathe fumes. Wear self-contained breathing apparatus and protective suit.
Additional advice	:	In case of fire: Evacuate area. Fight fire remotely due to the risk of explosion.

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Facts from MSDS

AGRAMKOW

Material Safety Data Sheet — Honeywell

2,3,3,3-Tetrafluoroprop-1-ene, HFO-1234yf

Version 1 | Revision Date 05/16/2008 | Print Date 05/16/2008

SECTION 6. ACCIDENTAL RELEASE MEASURES

Personal precautions	:	Immediately evacuate personnel to safe areas. Keep people away from and upwind of spill/leak. Wear personal protective equipment. Unprotected persons must be kept away. Wear self-contained breathing apparatus and protective suit. Eliminate all ignition sources if safe to do so. Avoid skin contact with leaking liquid (danger of frostbite). Ventilate the area. Vapors may travel to areas away from work site before igniting/flashing back to vapor source. Vapours are heavier than air and can cause suffocation by reducing oxygen available for breathing. Avoid accumulation of vapours in low areas. Unprotected personnel should not return until air has been tested and determined safe. Ensure that the oxygen content is >= 19.5%.
Environmental precautions	:	Prevent further leakage or spillage if safe to do so. The product evaporates readily. Discharge into the environment must be avoided.
Methods for cleaning up	:	Use explosion-proof equipment. No sparking tools should be used. Ventilate the area. Allow to evaporate.

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Facts from MSDS

AGRAMKOW

Material Safety Data Sheet — Honeywell

2,3,3,3-Tetrafluoroprop-1-ene, HFO-1234yf

Version 1 | Revision Date 05/16/2008 | Print Date 05/16/2008

SECTION 7. HANDLING AND STORAGE

Handling

Handling	:	Handle with care. Wear personal protective equipment. Do not breathe vapour. Avoid contact with skin, eyes and clothing. Use only in well-ventilated areas. Pressurized container. Protect from sunlight and do not expose to temperatures exceeding 50 °C.
Advice on protection against fire and explosion	:	Container hazardous when empty. Prevent the creation of flammable or explosive concentrations of vapour in air and avoid vapour concentration higher than the occupational exposure limits. Keep product and empty container away from heat and sources of ignition. Do not pressurize, cut, weld, braze, solder, drill, grind or expose containers to heat or sources of ignition. Take measures to prevent the build up of electrostatic charge. Electrical equipment should be protected to the appropriate standard. Use explosion-proof equipment. No sparking tools should be used. No smoking.

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Facts from MSDS

AGRAMKOW

Material Safety Data Sheet — Honeywell

2,3,3,3-Tetrafluoroprop-1-ene, HFO-1234yf

Version 1 | Revision Date 05/16/2008 | Print Date 05/16/2008

SECTION 8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Protective measures	:	Ensure that eyewash stations and safety showers are close to the workstation location. Do not breathe vapour. Avoid contact with skin, eyes and clothing.
Engineering measures	:	Use with local exhaust ventilation.
Eye protection	:	Safety goggles

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Facts from MSDS

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Material Safety Data Sheet — Honeywell

2,3,3,3-Tetrafluoroprop-1-ene, HFO-1234yf

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SECTION 10. STABILITY AND REACTIVITY

Conditions to avoid	:	Keep away from heat and sources of ignition. Pressurized container. Protect from sunlight and do not expose to temperatures exceeding 50 °C. Do not pressurize, cut, weld, braze, solder, drill, grind or expose containers to heat or sources of ignition. Decomposes under high temperature. Some risk may be expected of corrosive and toxic decomposition products.
Materials to avoid	:	Strong oxidizing agents Aluminium Magnesium Zinc
Hazardous decomposition products	:	Risk of formation of toxic pyrolysis products containing fluorine. In case of fire hazardous decomposition products may be produced such as: Hydrogen fluoride Carbonyl halides Carbon monoxide Carbon dioxide (CO2)

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AGRAMKOW Prototype

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Thanks
for your
attention

The AGRAMKOW Group
The safe choice

Udvikling af serviceudstyr til håndtering af alternative kølemedier til bilers Aircondition

Med udgangspunkt i EU's MAC-forordning vil det nuværende foretrukne kølemiddel, snart ikke længere være lovligt at anvende i nye bilmodellers aircondition anlæg. Et nyt kølemiddel, med den tekniske betegnelse R1234yf er blevet valgt af bilindustrien. Da kølemidlet er brændbart er det nødvendigt med nyt service udstyr til at servicere bilernes aircondition anlæg. Service udstyret forventes at skulle anvendes på Europas bilværksteder. AGRAMKOW har udviklet en prototype til det nye kølemiddel og prototypen er blevet succesfuldt testet ved flere af de store tyske bilfabrikanter.

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