



**1st IIR International
Conference
on the Application
of HFO Refrigerants**

2nd - 5th September 2018
IET Austin Court
Birmingham UK

Programme

Scientific Committee

Nacer Achaichia (Belgium), Jocelyn Bonjour (France), Gérald Cavalier (France), Alberto Coronas (Spain), Piotr Domanski (USA), Eckhard Groll (USA), Jacques Guilpart (France), Richard Lawton (UK), Robert Low (UK), Reinhard Rademacher (USA), Claudio Zillio (Italy), Baolong Wang (China)

Organising Committee

Andy Pearson (Chairman), Manuel Camacho, Judith Evans, Robert Kebby, Robert Low, Richard Lawton, Jeremy Miller, Chris Seeton, David Williamson, Eric Winandy and Lisa Waters

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Conference of the IIR Commissions B1, B2, C2, D1, D2, E1 and E2

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Instructions for oral presentations:

- All speakers and chairmen **MUST** meet in the room where they are giving their presentation 15 minutes prior to the beginning of the session.
- All speakers must check their laptop with the equipment on the podium before the session starts. If there is a problem connecting the laptop to the projector please let the chairman know as an alternative laptop can be provided.
- Please introduce yourself to the session chair and to the other speakers in the same session.
- Sit in the front row of the conference room.
- Due to limited time, the introduction by the session chair for each speaker will be very brief.
- When it is time for your presentation go to the podium as soon as the previous speaker finishes their presentation and has answered questions. You are required to plug your laptop into the projector.
- When you begin your presentation start immediately. Do not introduce yourself again. You only have 15 minutes for your presentation and 5 minutes for questions. You will not be allowed to over run this time.
- Be mindful of the time. Remember you only have 20 minutes to give your presentation and answer questions.
- Obey your chairman's instructions. You will be shown warning sign when you have 5 minutes and 2 minutes of your time left. If you have left time for questions at the end of your presentation, listen carefully to the questions from the audience and answer them briefly. If you cannot answer the questions briefly, ask for a private discussion after the session.

DAY 1 – Sunday 2nd September 2018

6.00pm - 9.00pm Pre-registration in the Boulton and Faraday Rooms. Conference Welcome Reception in Waterside Room

DAY 2 – Monday 3rd September 2018

8.00am - 5.00pm Registration desk open, Boulton and Faraday Rooms

Plenary session: Opening Ceremony, Keynote Address and Invited Speakers

Monday: 8.45am - 10.40am · Location: Kingston Theatre · Chairman: Andy Pearson ·

8.45	Introduction from Andy Pearson, Conference Organising Committee Chairman
8.50	Welcome from Didier Coulomb, Director, IIR
9.00	Keynote Address: Challenges of the New Landscape of Flammability. Kenji Takizawa, National Institute of Advanced Industrial Science and Technology
9.40	Policy Contexts and Implications of F-Gas Refrigerant Phase Down. Davinder Lail, Department for Environment, Food and Rural Affairs
10.10	Risk Analysis and Safety Assessment. Chris Seeton, Shrieve

10.40am - 11.10am **Coffee break**, The Waterside Room

Paper session 1 – Monday 3rd September: 11.15am - 12.55pm

Session 1a - System and component design in operation - Energy performance

Monday: 11.15am - 12.55pm · Location: Kingston Theatre · Chairman: Richard Lawton

11.15	Replacement of R404A at High Condensation Temperature Using R454C and R455A. <u>Jorge Ramiro Haro Ortuño</u> , Adrián Mota-Babiloni, Joaquín Navarro-Esbrí, Francisco Molés, Ángel Barragán-Cervera	1152
11.35	Eco-Efficiency Comparison of Supermarket Architectures. Nacer Achaichia, <u>Pawel Wisnik</u> , Robert Kebby	1148
11.55	HFO And Carbon Dioxide Cascade Systems With Zero GWP. <u>John Michael Lawrence</u>	1163
12.15	Reduced GWP Refrigerants for Residential and Commercial Air Conditioning Systems. Yang Zou, Ankit Sethi, <u>Samuel Yana Motta</u>	1102
12.35	A Review of the Most Studied HFO Thermophysical Properties and Heat Transfer Applications. <u>Sergio Bobbo</u> , Laura Fedele, Giulia Righetti, Claudio Zilio, J. Steven Brown, Giovanni di Nicola	1165

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Session 1b - Experience in operation - Commercial refrigeration and chillers

Monday: 11.15am - 12.55pm · Location: Lodge 1&2 · Chairman: Geoff Mills

11.15	Experimental Study on Diffusion Absorption Refrigeration Cycle using Low GWP Refrigerants. <u>Han Sol Jung</u> , Gahyeong Kim, Yong Tae Kang	1107
11.35	Application of HFO Blends in New and Existing Commercial Refrigeration Equipment – Operational Considerations and System Performance. <u>Charles Allgood</u> , Andrew Pansulla, Neil Roberts	1117
11.55	Influence of a Leak on A Liquid Cooling Chiller Performances Working With a Non-Azeotrope Mix. <u>Louis Goussé</u> , Marie-France Terrier, Fanny Destaing	1174
12.15	How to Minimize TEWI: Case History with Oil Free Centrifugal Chillers using R1234ze Refrigerant. <u>Francesco Fadiga</u>	1190
12.35	HFO-Based Alternative for R-410A in Commercial Refrigeration Barbara Haviland Minor, <u>Joshua Hughes</u>	1108

Session 1c - Short Course - Practical considerations in the use of HFOs and HFO blends

Monday: 11.15am - 12.55pm · Location: Lodge 3 · Course Leader: Neil Roberts

11.15	The workshop is aimed at consultants, designers, contractors, end users, and indeed anyone who is likely to use these products now or in the future. It will focus on practical aspects and what needs to be considered when approaching a project which will make use of these new refrigerants. The workshop will feature an overview of product development, how safety standards apply to their use, and some case studies highlighting what needs to be done in order to be compliant with regulations and standards.	S/CI
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12.55pm - 1.45pm Lunch, The Waterside Room

Paper session 2 - Monday 3rd September: 1.50pm - 3.30pm

Session 2a - Flammability in operation - Risk analysis

Monday: 1.50pm - 3.30pm · Location: Kingston Theatre · Chairman: Daniel Colbourne

1.50	Risk Assessment of Industrial Systems with A2L Refrigerants. <u>Andy Pearson</u>	1158
2.10	Applied Methods for Assessing Flammability Risks of HFO Refrigerants. John M Kondziolka, Nicole Briggs, Yanxu Zhang, <u>Thomas A Lewandowski</u>	1162
2.30	A Systematic Approach To Risk Assessing A2L Refrigeration Systems. <u>Dermot Cotter</u>	1188
2.50	Disproportionation Risk Study For Trifluoroethylene Composition as Low-GWP Refrigerants. <u>Hidekazu Okamoto</u> , Tetsuo Otsuka, Hiroki Hayamizu, Katsuya Ueno, Masato Fukushima	1132
3.10	Evaluation of Potential Use of R-1132a as a Refrigerant Blend Component. <u>Robert Low</u>	1183

Session 2b - Characteristics of HFO refrigerants - Thermophysical properties

Monday: 1.50pm - 3.30pm · Location: Lodge 1&2 · Chairman: Stefan Elbel

1.50	Binary Interaction Parameters for the Study of Hydrofluoroolefins Blends Using Cubic Equations of State. <u>Maria E. Mondejar</u> , Fredrik Haglind	1119
2.10	Surface Tension Measurement for Low GWP refrigerants HFO-1123 and HCFO-1224yd(Z). <u>Chieko Kondou</u> , Taro Tsuyashima, Yukihiro Higashi	1126
2.30	Development of the Equation of State for HCFO-1224yd(Z): Detailed and Extensive Evaluation of the Current Equation and Outlook for a New Equation. <u>Ryo Akasaka</u> , Yukihiro Higashi, Shigeru Koyama	1133
2.50	Speed of Sound and Dielectric Constant Measurements for a Mixture of HFO-1123 and R-32 in the Gas Phase. <u>Yuya Kano</u> , Yohei Kayukawa, Yoshitaka Fujita	1145
3.10	Measurements of Transport Properties of Low GWP Refrigerant HCFO-1224yd(Z) (cis-1-Chloro-2,3,3,3-tetrafluoropropene; CF ₃ CF=CHCl). <u>Akio Miyara</u> , Md. Jahangir Alam, Keishi Kariya	1139

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Session 2c - System and component design in operation – Compressors

Monday: 1.50pm - 3.30pm · Location: Lodge 3 · Chairman: Kevin Glass

1.50	Lubrication and Lubricant Development Considerations for Low Global Warming Potential (GWP) Refrigerants. <u>Julie Majurin</u> , Anthony Barthel	1114
2.10	Numerical Study on the Performance of Vapor Compression Liquid Chillers using R32 and R410A. <u>Jeong Hoon Lee</u> , Hoon Kang, Jongho Jung, Junyub Lim, Wonhee Cho, Yongchan Kim	1120
2.30	HFO Refrigerants for Chiller Applications. Nacer Achaichia, <u>Stefan Schuessler</u> , Ahmed Ali	1147
2.50	Sustainable Refrigerants For Comfort and Refrigeration. <u>Bachir Bella</u> , Hung Pham, Rajan Rajendran	1186
3.10	Performance of an Oil-free Linear Compressor using R1234yf. <u>Zhaohua Li</u> , Kun Liang	1128

3.30pm - 3.55pm Coffee break, The Waterside Room

Paper session 3 - Monday 3rd September: 4.00pm - 5.00pm

Session 3a - Legislation

Monday: 4.00pm - 5.00pm · Location: Kingston Theatre · Chairman: Bob Low

4.00	An Overview of How Flammable Refrigerants are Changing the RAC Landscape. <u>Stephen V Spletzer</u> , Patrick Coughlan, Joachim Gerstel	1122
4.20	Setting Occupational Exposure Limits for HFO Refrigerants: Understanding the Process. <u>Thomas A Lewandowski</u>	1161
4.40	HFO Leak Detection Technologies & Strategies To Reduce Refrigerant Leakage. <u>Tom Burniston</u>	1104

Session 3b - Responsible use in operation - Life-Cycle Climate Performance (LCCP)

Monday: 4.00pm - 5.00pm · Location: Lodge 1&2 · Chairman: Steve Gill

4.00	Challenges and Opportunities to Design Chillers Using Low and Medium GWP Fluids. <u>Paul de Larminat</u>	1167
4.20	The Opportunity for Rapid Transition to Energy Efficient Low –GWP Alternatives for Building Air Conditioning Chillers. Stephen Andersen, Ray Gluckman, Alexander Hillbrand, <u>Mike Thompson</u>	1177
4.40	Study on Environmental and Health Effects of HFO Refrigerants. David Fleet, James Hanlon, Kate Osborne, <u>Max La Vedrine</u> , Paul Ashford	1187

Session 3c - Lubricants in operation

Monday: 4.00pm - 4.40pm · Location: Lodge 3 · Chairman: Chris Seeton

4.00	Experiences with Next Generation Low GWP Refrigerants in Screw Chillers. <u>Ken Schultz</u> , Elyse Sorenson, Morgan Herried	1111
4.20	Experiences with Next Generation Low GWP Refrigerant R452A in Transport Refrigeration Products. <u>Stephen Kujak</u> , Elyse Sorenson, Dermott Crombie	1112
	Withdrawn	

Commission Meetings 5.05pm to 6.00pm

Commission E1 and E2 joint meeting in the Lodge 1&2

Commission B2 meeting in the Lodge 3

Conference Dinner

The conference dinner is happening at the Birmingham Repertory Theatre. The theatre is a short walk from the conference venue and delegates will make their own way there. The theatre can be found on Centenary Square, Broad Street, Birmingham, B1 2EP. The dress code is smart casual. A map to the dinner venue can be found in the conference bag.

Timings

7.00pm: Doors open for the welcome reception

7.30pm: Call to dinner

9.45pm: Student prize and speeches followed by after dinner entertainment. 11.00pm: Bar closes

1st IIR International Conference on the Application of HFO Refrigerants

DAY 3 - Tuesday 4th September 2018

8.00am - 6.00pm Registration desk open, Boulton and Faraday Rooms

Plenary session: Keynote Address and Plenary Papers

Tuesday: 8.55am - 10.40am · Location: Kingston Theatre · Chairman: Judith Evans

8.55	Welcome from Steve Gill FlnstR IOR President	
9.00	Keynote Address: HFOs In Use - Feedback from End Users. Rajan Rajendran, Emerson Climate Technologies Industrial Science and Technology	
9.40	Selecting Refrigerants During the Global Phase-Down of HFCs. Ray Gluckman, Gluckman Consulting	1172
10.10	Atmospheric Chemistry and Environmental Impact of some HFO and HFCO Refrigerants. Tim Wallington, Ford Motor Company, Rajiv Singh, Honeywell International. Presenter Rajiv Singh	1149

10.40am - 11.10am Coffee break, The Waterside Room

Paper session 4 - Tuesday 4th September: 11.15am - 12:55pm

Session 4a - Flammability in operation - Design considerations

Tuesday: 11.15pm - 12.55pm · Location: Kingston Theatre · Chairman: Kevin Glass

11.15	Hot Surface Ignition Test Method and Data for Class 2L Refrigerants. Mary Elizabeth Koban, <u>Nina E Gray</u>	1109
11.35	Assessment of Leakage Rate and Durability of Field-made Mechanical Joints for Systems Using Low-GWP Flammable Refrigerants (ASHRAE RP-1808). <u>Neal Lawrence</u> , Sharat Raj, Stefan Elbel	1115
11.55	Minimum Airflow Rates to Dilute A2L Refrigerant Leaks from Refrigeration Systems. <u>Daniel Colbourne</u> , Kwok On Suen	1189
12.15	AHRI Research Activities on Flammable Refrigerants. <u>Xudong Wang</u>	1106
12.35	Withdrawn	

Session 4b - System and component design in operation - Energy performance and heat exchangers

Tuesday: 11.15pm - 12.55pm · Location: Lodge 1&2 Theatre · Chairman: Baolong Wang

11.15	Performance Evaluation of HFO-1234yf as a Substitute for R-134a in a Household Freezer/Refrigerator. <u>Jangseok Lee</u> , Myungryul Lee, Simon Jeon	1127
11.35	Performance of Newly Developed Hydrofluoroolefin Blowing Agents. <u>Josep Gimeno</u> , Karim Tarzi	1146
11.55	Economic and Climate Advantages of Using Secondary Loop Systems (SL-MACS) for HFO-1234yf in Mobile Air Conditioning. Stephen O. Andersen, James A. Baker, Sourav Chowdhury, Timothy Craig, Sangeet Kapoor, Jagvendra Meena, Prasanna Nagarhalli, <u>Nancy J. Sherman</u> , Melinda Soffer, Kristen N. Taddonio	1178
12.15	Low GWP Refrigerant R454A for Commercial Refrigeration. <u>Felix Flohr</u> , Hitomi Arimoto, Shun Ohkubo	1134
12.35	Two-Phase Heat Transfer Performance of Ternary Mixtures of HFOs and HFCs Inside Channels. Marco Azzolin, Arianna Berto, Stefano Bortolin, <u>Davide Del Col</u>	1179

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Refrigerants



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Session 4c - Short Course - Safety, efficiency, reliability and containment of HFOs

Tuesday: 11.15pm - 12.55pm · Location: Lodge 3 · Course Leaders: Jane Gartshore & Marco Buoni

11.15	REAL Alternatives is a course designed to provide information on the safe use of alternatives such as ammonia, hydrocarbon, carbon dioxide and low GWP HFCs / HFOs. This European learning programme was developed as part of a project offering innovative blended learning - a mix of e-learning, face-to-face training materials, practical exercises, assessments and an e-library of learning resources and was brought together using industry knowledge and expertise from across Europe about alternative refrigerants. Conference delegates will have the unique opportunity to study some of the REAL Alternatives modules in a classroom environment with a lead expert from the field of alternative refrigerants and leak reduction. The course will focus on HFO refrigerants and covers the safety, efficiency, reliability and containment of HFO refrigerants. Those taking part will be able to undertake the course assessments and will be issued with certification.	S/C2
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12.55pm - 1.45pm Lunch, The Waterside Room

Paper session 5 - Tuesday 4th September: 1.50am - 3.30pm

Session 5a Characteristics of HFO refrigerants - Heat transfer performance

Tuesday: 1.50pm - 3.30pm · Location: Kingston Theatre · Chairman: David Blackhurst

1.50	Experiences with Next Generation Low GWP Refrigerants in Centrifugal Chillers. <u>Stephen Kujak</u> , Ken Schultz, Elyse Sorenson	1110
2.10	Evaporation Heat Transfer of HFC-32/HFO-1123 (60/40 mass%) Flow in a horizontal Microfin tube. <u>Chieko Kondou</u> , Shigeru Koyama	1129
2.30	Saturated Vapour Condensation of R-1234ze(Z) Inside a 4 mm ID Horizontal Smooth Tube. Giovanni A. Longo, Simone Mancin, Giulia Righetti, <u>Claudio Zilio</u>	1141
2.50	HFO-1234ze(E) Flow Boiling Heat Transfer Inside a 4.0 mm OD Microfin Tube. <u>Andrea Diani</u> , Luisa Rossetto	1171
3.10	An Experimental Investigation on Flow Boiling Heat Transfer of Refrigerants HFO-1234yf and HFC-134a in Microchannels. Hamid Nalbandian, <u>Chien-Yuh Yang</u> , Kuan-Ting Chen	1184

Session 5b - Experience in operation - Heat pumps and power cycles

Tuesday: 1.50pm - 3.30pm · Location: Lodge 1 & 2 · Chairman: Andrew Gigiel

1.50	Testing of R245fa and R1233zd(E) in a High Temperature Waste Heat Recovery Application Utilizing a Scroll Expander. Alejandro Carlos Lavernia, <u>Davide Ziviani</u> , Nigora Gafur, Kunal Bansal, Bryce Shaffer, Eckhard Groll	1140
2.10	HFO-1336mzz(Z) and HCFO-1233zd(E) as Alternatives to HFC-245fa In Organic Rankine Cycles for Micro-Scale Low-Temperature Applications. Joaquín Navarro-Esbrí, Francisco Molés, <u>Marta Amat-Albuixech</u> , Adrián Mota-Babiloni, Carlos Mateu-Royo	1153
2.30	Optimal Volume Ratio of Two Stage Rotary Compressor Using R32/R1234ze(E) Mixtures. Zuo Cheng, <u>Baolong Wang</u> , Wenxing Shi, Xianting Li	1173
2.50	Comparison Between HFCs And HFO/HFC Blends in a Commercial Heat Pump. Richard Lawton, <u>Chris Rhodes</u>	1156
3.10	A Non-Flammable Low GWP Refrigerant for Centrifugal Chillers and High Temperature Heat Pumps: R-1336mzz(Z). <u>Jason Juhasz</u> , Konstantinos {Kostas} Kontomaris	1135

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Session 5c - Short course - Tips and techniques for refrigerant property simulation - Challenges presented in simulating HFOs and HFO blends

Tuesday: 1.50pm - 3.30pm · Location: Lodge 3 · Course Leader: Ian Bell

1.50	This workshop will cover the state-of-the-art thermophysical property models in use today and how to maximise the accuracy and computational efficiency of these models. Topics to be covered include: <ul style="list-style-type: none"> Understanding the model formulations used and the implications of these models for end users How to use NIST REFPROP, and interface with it in a computationally efficient manner How to make your calculations faster with tabular interpolation 	S/C 3
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3.30pm - 3.55pm Coffee break, The Waterside Room

Paper session 6 - Tuesday 4th September: 4:00am - 5.40pm

Session 6a - Characteristics of HFO refrigerants - Performance modelling and fluid flow characteristics

Tuesday: 4.00pm - 5.20pm · Location: Kingston Theatre · Chairman: Davide Ziviani

4.00	A Visual Representation of Refrigerant Characteristics – What do HFOs Look Like? <u>Andy Pearson</u>	1157
4.20	A Comparison of the Energy and Exergy performance of R1234yf and R134a in a Compression Stage using Computational Intelligence Techniques. <u>Juan Manuel Barroso Maldonado</u> , Juan Manuel Belman Flores, Armando Gallegos Muñoz, Joaquín Navarro Esbrí, Sergio Ledesma Orozco	1124
4.40	Total Equivalent Warming Impact Analysis of HFO Blends and CO ₂ in Refrigeration Applications. <u>Charles Allgood</u> , Andrew Robert Pansulla	1138
5.00	Refrigerants With Low Environmental Impact For Refrigeration Systems. Michael Petersen, Gustavo Pottker, Ankit Sethi, <u>Samuel Yana Motta</u>	1103

Session 6b - Characteristics of HFO refrigerants - Thermophysical properties

Tuesday: 4.00pm - 5.40pm · Location: Lodge 1&2 · Chairman: Steve Gill

4.00	Theoretical Model for Calculating HFO Based Refrigerant Performance in Simple Flooded Evaporator Systems. <u>Neil Roberts</u> , Luke Simoni	1121
4.20	Stable R-1233zd(E) For Energy Recovery Applications. <u>Wissam Rached</u> , Sarah Kim, Laurent Abbas	1137
4.40	Analysis of Vapor Pressure and VLE of HFOs, HCFOs, and their Blends with Cubic Equations of State. Giovanni Di Nicola, Gianluca Coccia, Mariano Pierantozzi, <u>Sebastiano Tomassetti</u> , Roman Stryjek	1166
5.00	Influence of HFO Refrigerants on the Viscoelastic Behavior of Elastomers. <u>Sebastian Eyerer</u> , Peter Eyerer, Christoph Wieland, Hartmut Spliethoff	1169
5.20	Study of R-404a and R-488a Refrigerants in Low Temperature Refrigeration of Electronics. <u>Martin Doubek</u> , Václav Vacek	1180

Session 6c - Flammability in operation - Risk analysis

Tuesday: 4.00pm - 5.40pm · Location: Lodge 3 · Chairman: Dermot Cotter

4.00	Development, Testing And Evaluation of 2L Refrigerants. <u>Robert Low</u> , Christophe Proust	1150
4.20	An Experimental and Numerical Study of Refrigerant Leaks in Refrigerated Transport Containers. <u>Hugh O'Reilly</u> , Tomas Kohoutek, Dermott Crombie, Rory Monaghan, Padraig Molloy	1116
4.40	HFO-1234yf, a Refrigerant of Choice in Mobile Air Conditioning. <u>Nacer Achaichia</u>	1144
5.00	Review of Methodology to Set Safety Factors for A2L Flammable Refrigerant Being Adopted by Product Safety Standards. <u>Bill Hansen</u> , Steve Kujak	1118
5.20	Risk Assessment of Catastrophic Leak of R452B from Packaged Unit into a Residential Space. <u>Ahmed Elatar</u> , Ahmad Abu-Heiba, Viral Patel, Dean Edwards, Van Baxter, Omar Abdelaziz, Mingkan Zhang	1105

1st IIR International Conference on the Application of HFO Refrigerants

Plenary Session: Closing Ceremony

Tuesday: 5.45pm - 6.00pm Location: Kingston Theatre · Chairman: Andy Pearson

5.45pm Overview of the conference and close from Andy Pearson, Conference Organising Committee Chairman

6.00pm Conference close

DAY 4 – Wednesday 5th September 2018

All full conference delegates have a tour included in their conference package: **Places must be pre-booked.**

Coaches depart from outside Austin Court promptly at the time shown below.

Departs 8.00am Returns 1.00pm	T1. Heat recovery and energy generation The Spirax Sarco Technology Centre and Steam and Thermal Energy Laboratory demonstration centre tour will focus on a new Controlled Phase Cycle (CPC) solution using refrigerant HFO R1233zd that can recover useful energy from low-grade (less than 100°C) waste heat produced by many industrial processes and buildings, giving companies a new opportunity to generate electricity and reduce their energy costs substantially. Spirax Sarco is a leading provider of steam system solutions and training, with a global presence of over 1,300 engineers in 34 countries. The training facility at the Technology Centre also includes a fully working boiler house, demonstration rigs providing hands-on fault finding and assembly exercises.
Departs 9.10am Returns 12.15 pm	T2. Retail display cabinet manufacturing Carter Retail Equipment manufactures refrigerated display cases, cold stores and door systems from their 150,000 sq/ft site in Kitts Green, Birmingham. The state-of-the-art manufacturing plant houses the latest technology, including a semi automated assembly line and in line test facility, producing equipment for a range of refrigerants including HFO and hydrocarbon. The site also includes a research & development and refrigerant testing capability with 3D CAD, environmental test chambers and test rigs.
Departs 9.30am Returns 12.30 pm	T3. Tesco Supermarket using HFOs This tour will take delegates to a Tesco Superstore in Aston Lane which first opened in 2008 and has now been converted to R448A. The equipment on site includes containerised packs - two HT with refrigerant charges of approximately 260kg and two LT with charges of approximately 160kg. The engineering team from this major supermarket will discuss the challenges and opportunities that were encountered during the retrofitting process and how the system is operating now it has been installed.
Departs 9.30am Returns 12.30 pm	T4. Training Centre The EEF Technology Hub in Aston is an £11m development and training centre created by the UK manufacturing and engineering industry, that opened in 2016. Its' 50,000 sq ft of training space has been designed and equipped to replicate real-life modern engineering and manufacturing workplaces. The site includes state of the art tool room, CAD/CNC facilities, robotic cells automated factory, fully equipped electrical bays, virtual welding as well as 14 welding bays and 120 manufacturing machines. The Technology Hub is used extensively by major companies such as Jaguar Landrover for apprentice training. .
Departs 9.45am Returns 11.45 am	T5. Guided Historical Walking Tour Explore Birmingham's engineering and industrial past with a local tour guide. The city has many industrial revolution-era landmarks that show its history as a manufacturing powerhouse. Delegates will hear about Birmingham's industrial pioneers and Victorian heritage while visiting interesting locations around the city.

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