

2.5

# Overview of AHRI Risk Assessment Studies for A2L Refrigerants

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# Overview

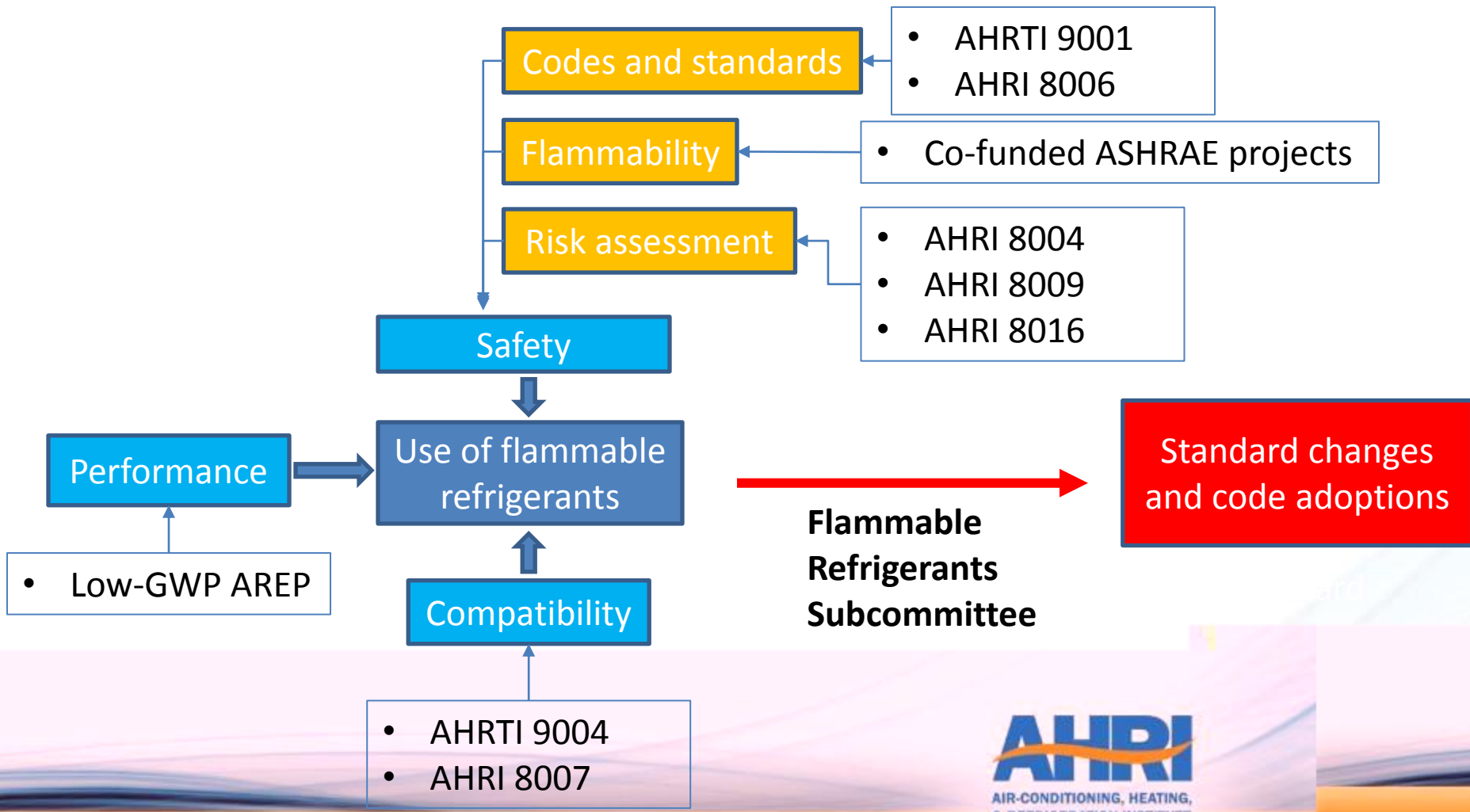
- **Introduction**
- **Equipment type**
- **Methodology**
- **Results**
- **Conclusions**



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# AHRI Research Activities on Flammable Refrigerants



# Introduction

## ➤ Risk assessment completed/ongoing:

- Residential heat pumps
- Commercial refrigeration products
- Rooftop units

## ➤ Refrigerants

- R-32
- R-1234yf
- R-1234ze

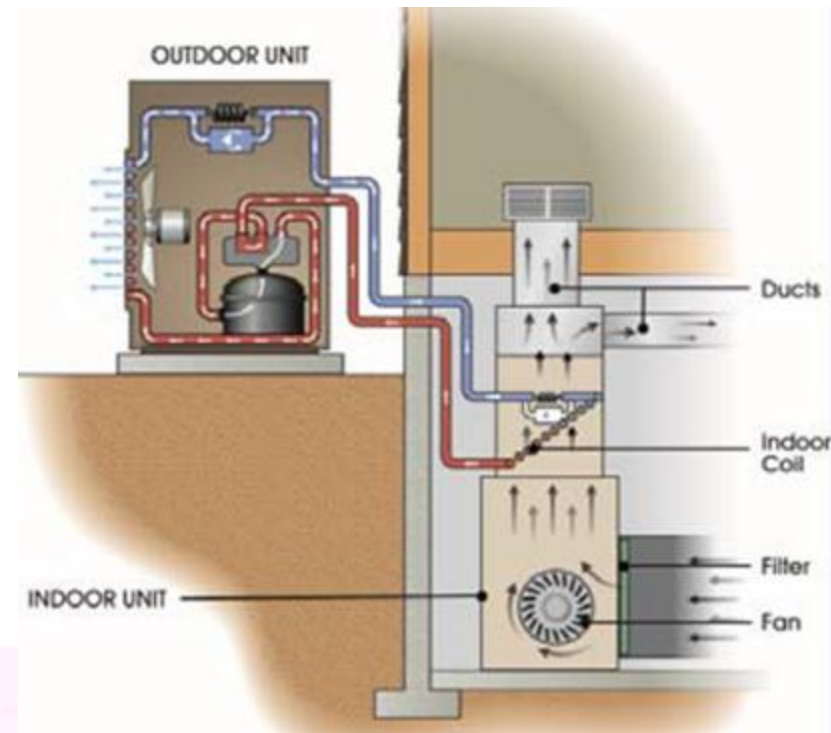


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# Equipment

- **Residential heat pumps**
  - ducted split heat pumps

Outdoor Unit	Indoor Unit (with blower on/off)
Outside	Basement
	Garage
	Attic
	Utility closet

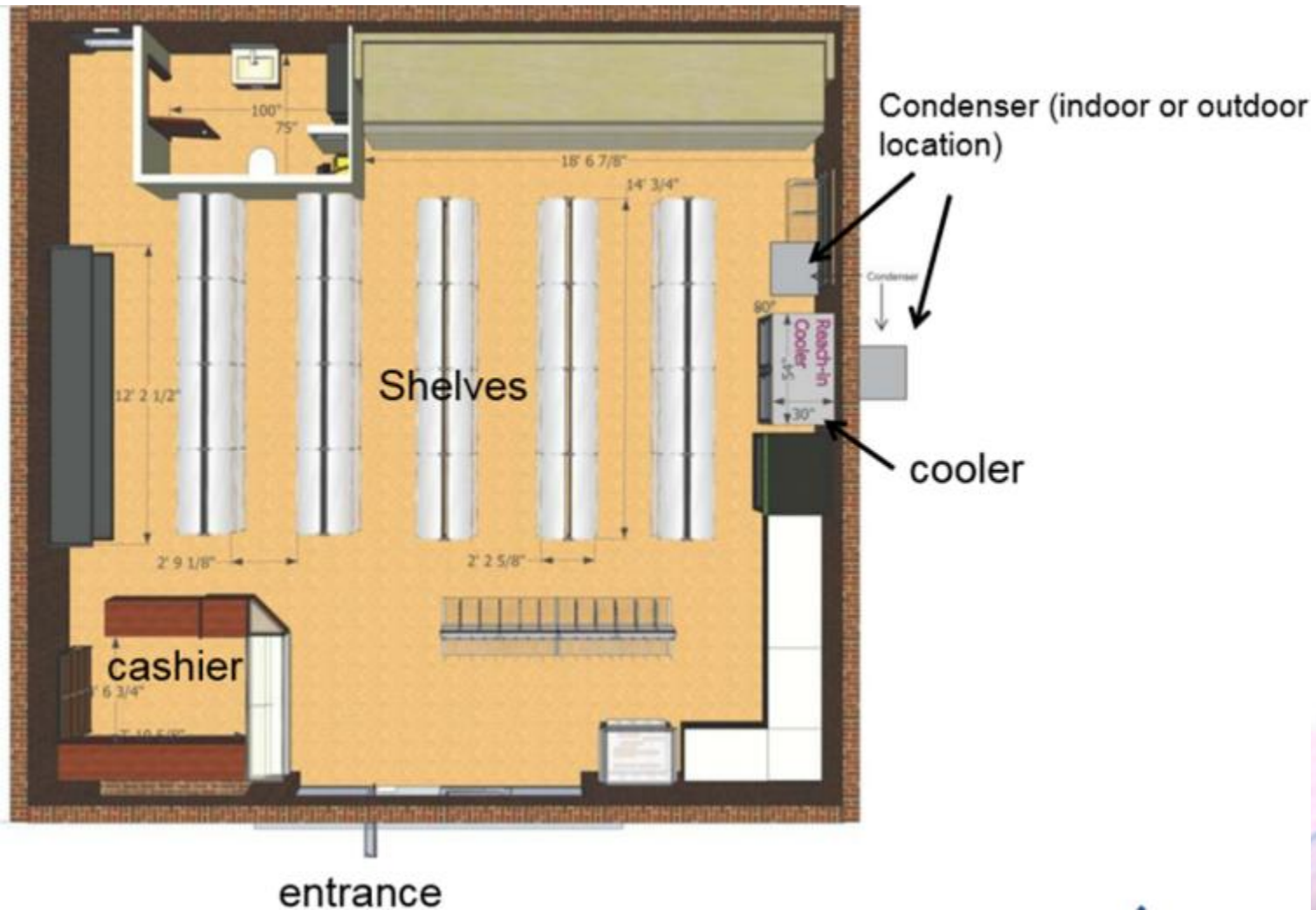


# Equipment

## ➤ Commercial refrigeration product

Leak Type/Equipment	Location
Large (rupture) and small (corrosion-induced) leaks in a self-contained reach-in cooler located in:	A convenience store. A kitchen in a small restaurant. A lunch counter.
Large (rupture) and small (corrosion-induced) leaks in a self-contained walk-in cooler located in:	A convenience store. A kitchen in a small restaurant.
Large (rupture) and small (corrosion-induced) leaks in a single condensing unit located outdoors and connected to:	A walk-in cooler in a convenience store. A walk-in cooler associated with a kitchen in a small restaurant.

# Convenience Store



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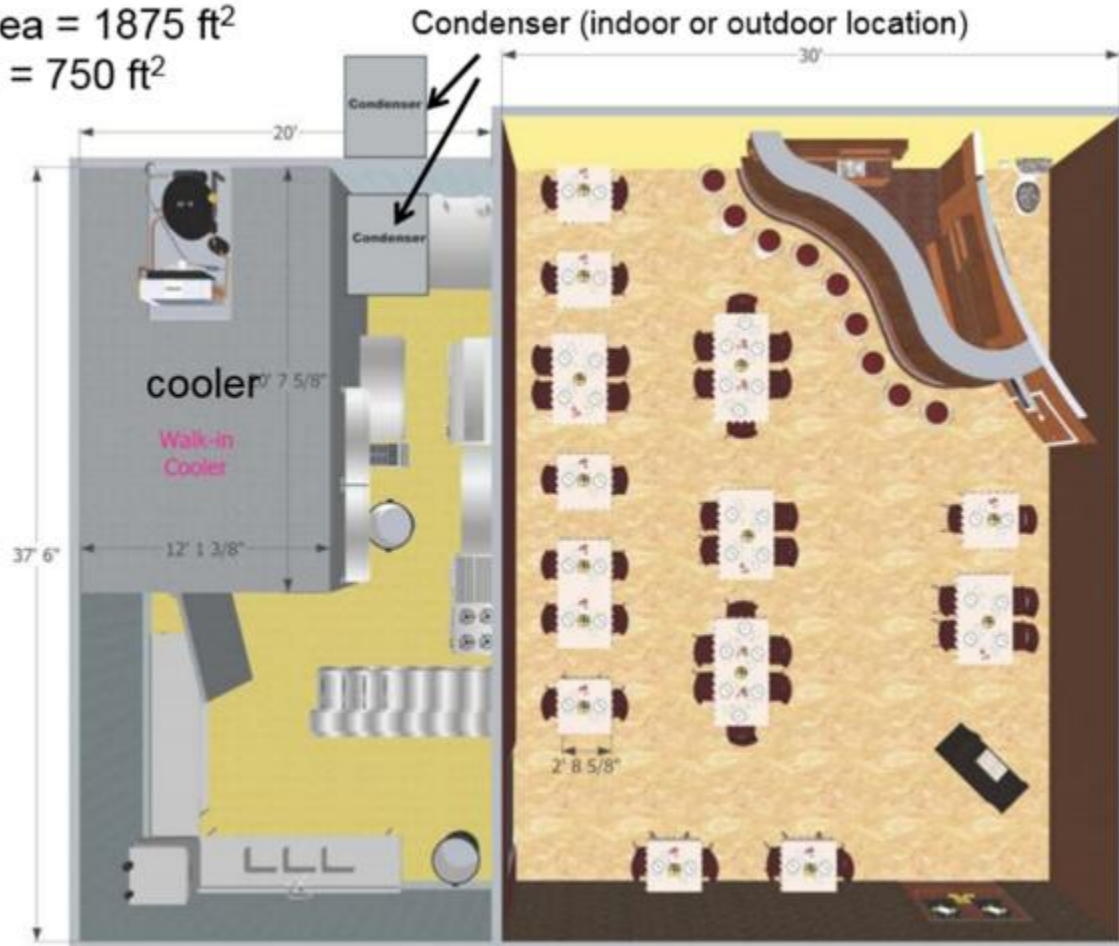
# Small Restaurant/Lunch Counter





# Commercial Kitchen

Total Area = 1875 ft<sup>2</sup>  
Kitchen = 750 ft<sup>2</sup>

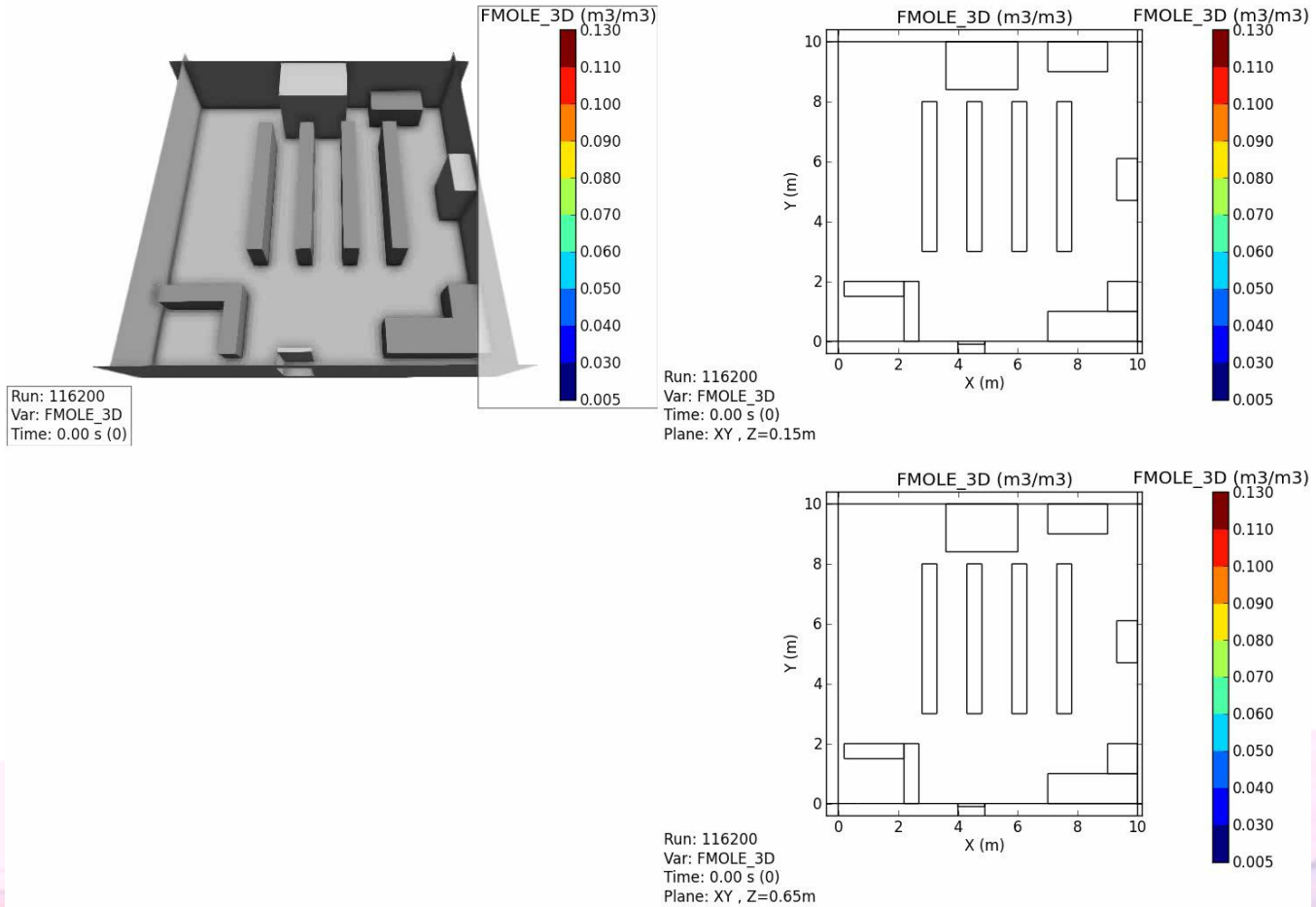


entrance

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# CFD Simulation



# CFD Results

**Table 3.4 Summary of Results of CFD Modeling for R-32**

Scenario (Leak Rate)	Time LFL Exceeded (s)	Maximum Conc. at Monitoring Points (%)	Time LFL Exceeded (s)	Comment
<b>Basic Scenarios</b>				
Restaurant Kitchen	0	3.32	0	Concentrations well below the LFL in all locations.
Lunch Counter	0	0.41	0	Concentrations well below the LFL in all locations.
Convenience Store	0	0.63	0	Concentrations well below the LFL in all locations.
<b>Exploratory Scenarios</b>				
Restaurant Kitchen (Walk-in Cooler Door Closed)	0	7.12	0	Concentrations well below the LFL in all locations.

# CFD Results

**Table 3.5 Summary of Results of CFD Modeling for R-1234ze(E)**

Scenario (Leak Rate)	Time LFL Exceeded (s)	Maximum Conc. at Monitoring Points (%)	Time LFL Exceeded (s)	Comment
<b>Basic Scenarios</b>				
Restaurant Kitchen	0	1.43	0	Concentrations well below the LFL in all locations.
Lunch Counter	0	0.31	0	Concentrations well below the LFL in all locations.
Convenience Store	0	0.30	0	Concentrations well below the LFL in all locations.
<b>Exploratory Scenarios</b>				
Restaurant Kitchen (Walk-in Cooler Door Closed)	0	3.38	0	Concentrations well below the LFL in all locations.

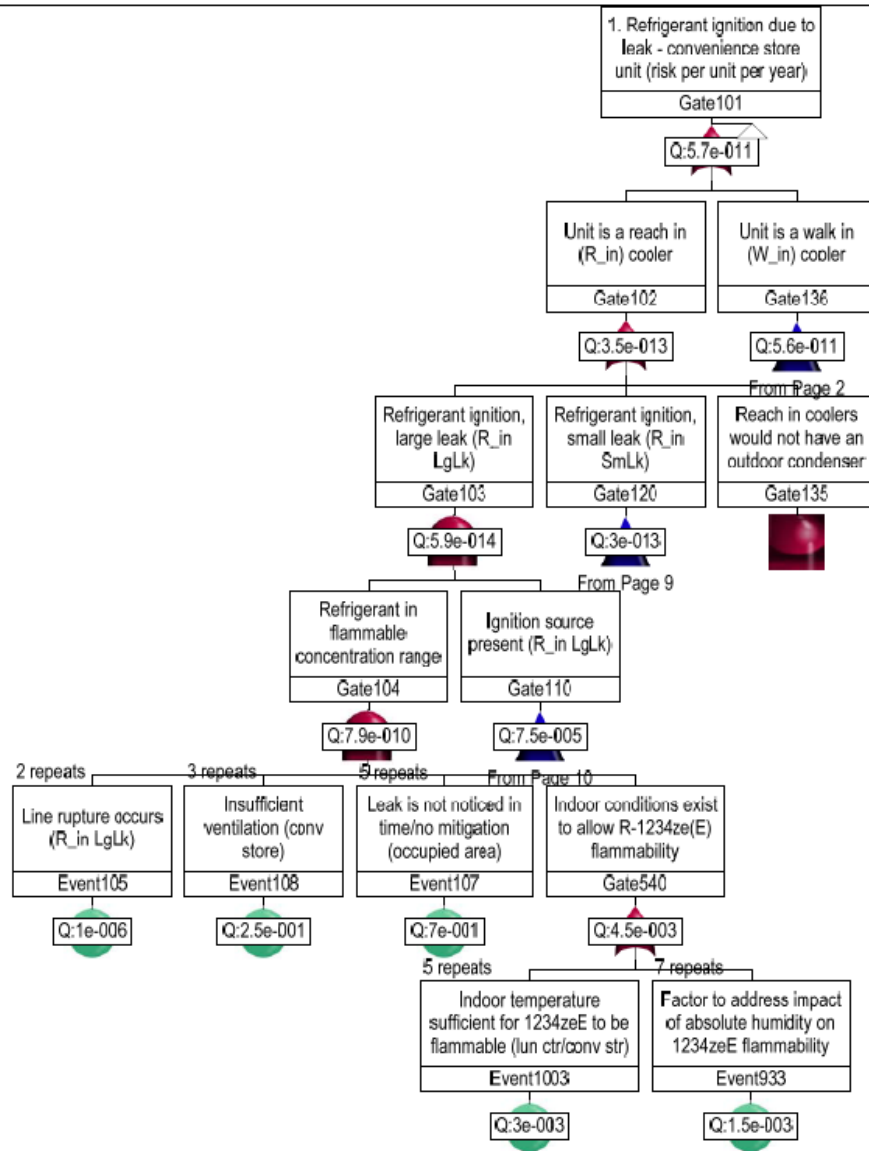
# Experimental Study/Concentration Measurements



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# Fault Tree Analysis





# FTA Results

Table 4.1 Results of FTA

Scenario	Fault Tree	Risk of Refrigerant Ignition (Events per Unit per Year)		
		R-32	R-1234ze(E)	R-1234yf
Convenience Store Scenario	1	$1 \times 10^{-9}$	$6 \times 10^{-11}$	$2 \times 10^{-10}$
Inside event <sup>(1)</sup>				
Reach-in		$8 \times 10^{-11}$	$4 \times 10^{-13}$	$8 \times 10^{-11}$
Walk-in		$6 \times 10^{-11}$	$3 \times 10^{-13}$	$6 \times 10^{-11}$
Outside event <sup>(2)</sup>		$1 \times 10^{-9}$	$6 \times 10^{-11}$	$6 \times 10^{-11}$
Lunch Counter Scenario <sup>(3)</sup>	2	$2 \times 10^{-10}$	$7 \times 10^{-13}$	$2 \times 10^{-10}$
Restaurant Kitchen Scenario	3	$3 \times 10^{-9}$	$3 \times 10^{-10}$	$2 \times 10^{-9}$
Inside event				
Reach-in		$6 \times 10^{-10}$	$2 \times 10^{-10}$	$6 \times 10^{-10}$
Walk-in		$9 \times 10^{-10}$	$4 \times 10^{-10}$	$9 \times 10^{-10}$
Outside event		$1 \times 10^{-9}$	$6 \times 10^{-11}$	$6 \times 10^{-11}$
Repair Scenario	R	$1 \times 10^{-11}$	$2 \times 10^{-13}$	$4 \times 10^{-12}$



# Ongoing project

## ➤ Rooftop Unit

Equipment Types	Building Types	Conditions
25T Roof Mount	Office	The FTA will assess risk under the following three conditions: <ol style="list-style-type: none"><li>1. Installation</li><li>2. Servicing</li><li>3. Operation</li></ol>
5T Ground Mount		
15T Roof Mount	Commercial Kitchen	

# Thank you for your attention!



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