CalFIRE A2L 2022

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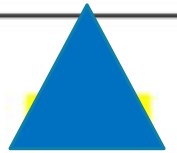
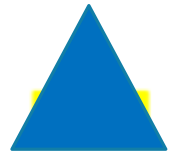
New HVAC Installation with New Line-set

R-410A Residential System	A2L Residential System	A2L vs. R-410A Differences
Follow OEM guidelines for line sizing, length	Follow OEM guidelines for line sizing, length	
Field joints exposed for visual inspection prior to covering/enclosing per ASHRAE 15 and Bldg Codes	Field joints exposed for visual inspection prior to covering/enclosing per ASHRAE 15 and Bldg Codes	
Field joint made at the unit - Brazed, welded or mech connections	Field joint made at the unit - Brazed, welded or mech connections - Indoor mechanical connections must comply with ISO 14903, or other reqs	
Testing - Pressure test - Vacuum test - Leak check (handheld leak detector)	Testing - Pressure test - Vacuum test - Leak check (handheld leak detector)	

New Install with Existing Line-set –Exposed Piping

R-410A Residential System	A2L Residential System	A2L vs. R-410A Differences
Follow OEM guidelines for line sizing, length	Follow OEM guidelines for line sizing, length	
Inspect lines for condition/cleanliness	Inspect lines for condition/cleanliness	
Flush lines, if necessary	Flush lines, if necessary	
Field joints exposed for visual inspection prior to covering/enclosing per ASHRAE 15 and Bldg Codes	Field joints exposed for visual inspection prior to covering/enclosing per ASHRAE 15 and Bldg Codes	
Field joint made at the unit - Brazed, welded or mech connections	Field joint made at the unit - Brazed, welded or mech connections - Indoor mechanical connections must comply with ISO 14903, or other reqs	
Testing - Pressure test - Vacuum test - Leak check (handheld leak detector)	Testing - Pressure test - Vacuum test - Leak check (handheld leak detector)	

New Install with Existing Line-set – Hidden Piping

R-410A Residential System	A2L Residential System	A2L vs. R-410A Differences
Follow OEM guidelines for line sizing, length	Follow OEM guidelines for line sizing, length	✓
Testing - Pressure test - Vacuum test - Leak check (handheld leak detector)	Testing - Pressure test - Vacuum test - Leak check (handheld leak detector)	✓

- **California Building Code has required visible inspection of piping upon installation as far back as could be confirmed.**
- **Verify piping integrity (whether existing or new): pressure test, vacuum check, and leak check**

Research

Completed Research on Flammable Refrigerants*

- Testing
  - **AHRTI-9007: Benchmarking Risk by Whole Room Scale Leaks and Ignitions Testing**
  - AHRTI-9013: A2L Consequence Study
  - AHRTI-9012/Oak Ridge National Laboratory (ORNL): Real-world Leak Assessments of Alternative Flammable Refrigerants-Phase I
  - AHRTI-9008: Investigation of Hot surface Ignition Temperature (HSIT) for A2L Refrigerants
  - AHRI-8017: Investigation of Energy Produced by Potential Ignition Sources in Residential Application
  - NFPA: Evaluation of the Fire Hazard of ASHRAE Class A3 Refrigerants in Commercial Refrigeration Applications
  - Carrier: Electric Heater Testing
  - Carrier: Turbulent deflagrations of mildly flammable refrigerant-air mixtures
- Modeling
  - ORNL: Investigate the Proper Basis for Setting Charge Limits of A2L, A2, and A3 for Various Types of Products
- Servicing
  - ASHRAE-1807:Guidelines for Flammable Refrigerant Handling, Transporting, Storing and Equipment Servicing, Installation and Dismantling
  - ASHRAE-1808: Servicing and Installing Equipment using Flammable Refrigerants: Assessment of Field-made Mechanical Joints
  - AHAM Safe Servicing of Household Appliances with Flammable Refrigerants: Recommended Practices
  - NFPA: Flammable refrigerants firefighter training: Hazard assessment and demonstrative testing
- Detection
  - AHRTI-9009: Leak Detection of A2L Refrigerants in HVACR Equipment

*This is not a comprehensive list (Japan, Europe and Manufacturers have done extensive studies)

Research on Flammable Refrigerants*

Completed - Risk Assessment

- AHRI-8004: Risk Assessment of Residential Heat Pump Systems Using 2L Flammable Refrigerants
- AHRI-8009: Risk Assessment of Refrigeration Systems Using A2L Flammable Refrigerants
- AHRI-8016: Risk Assessment of Rooftop Units Using A2L Refrigerants

- Ongoing projects in US
  - AHRTI-9014: Assess Refrigerant Detector Characteristics for Use in HVACR Equipment
  - AHRTI-9015: Assessment of Mitigation Effectiveness for Air-Conditioning and Refrigeration Equipment
  - AHRI 8023: Risk Assessment of Transport Refrigeration Systems Using Flammable Refrigerants
  - Oak Ridge National Laboratory (ORNL): Real-world Leak Assessments of Alternative Flammable-Phase II
  - NIST: Modeling tools for low-GWP Refrigerant Blends Flammability
  - ASHRAE-1806: Flammable Refrigerants Post-Ignition Simulation and Risk Assessment Update
  - ASHRAE-1855: Determination of the Impact of Combustion Byproducts on the Safe Use of Flammable Fluorinated Refrigerants

Research outside US

- Japanese Industry Risk Assessment of Mildly Flammable Refrigerants
- Japanese Industry Risk Assessment for Safe Use of A3 Refrigerants

*This is not a comprehensive list (Japan, Europe and Manufacturers have done extensive studies)

Research 9007-01

http://www.ahrinet.org/App_Content/ahri/files/RESEARCH/Technical%20Results/AHRI_9007-01_Final_Report.pdf

AHRTI 9007-01

Final report AHRTI Project 9007-01 Benchmarking Risk by Whole Room Scale Leaks and Ignitions Testing of A2L Refrigerants

The project investigation plan is presented in Figure 1.

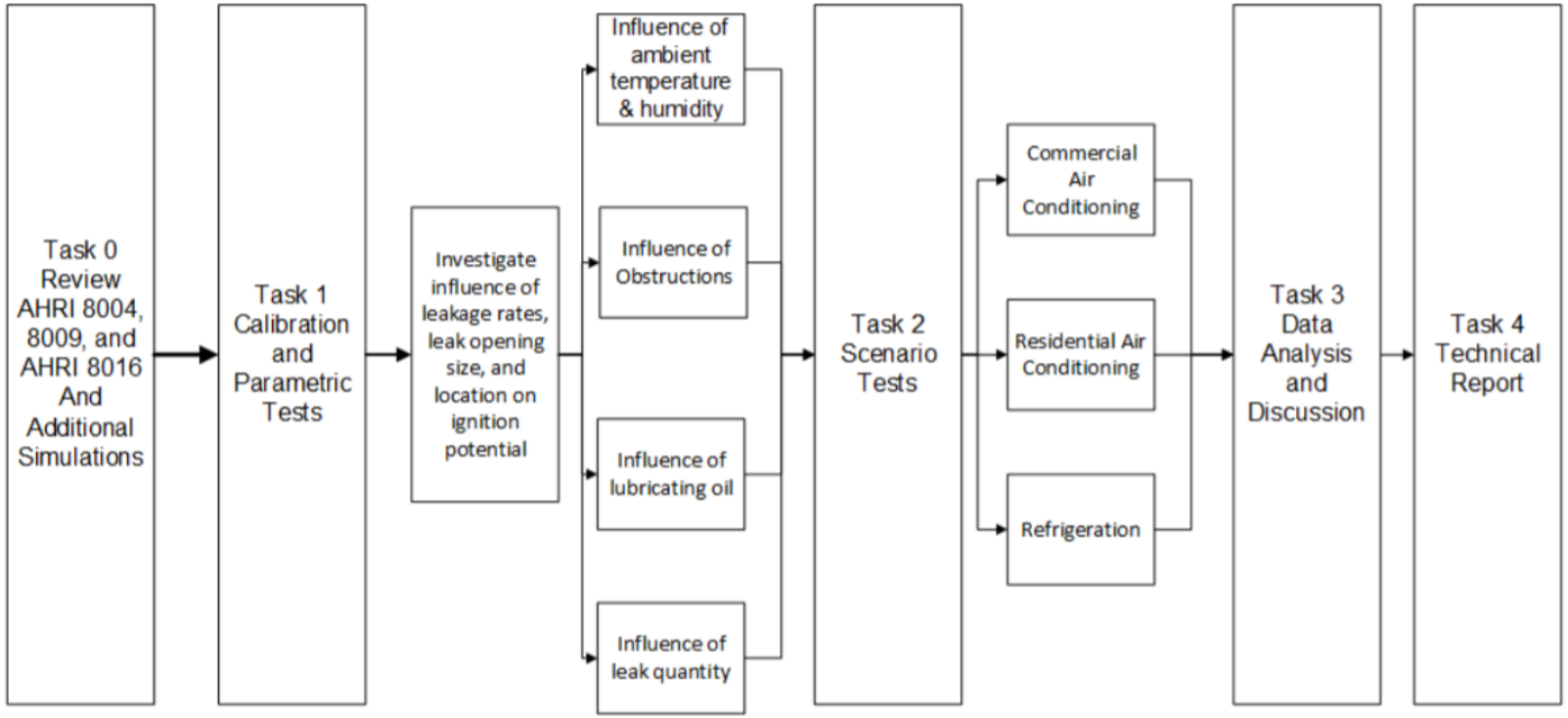


Figure 1 – Technical Plan

Flammable Zones - Initial Research Observations

High (8ft) release: Concentrations **below** LFL due to mixing

Low release: Concentrations above UFL

Mid-range without barrier: Concentrations **below** LFL due to mixing

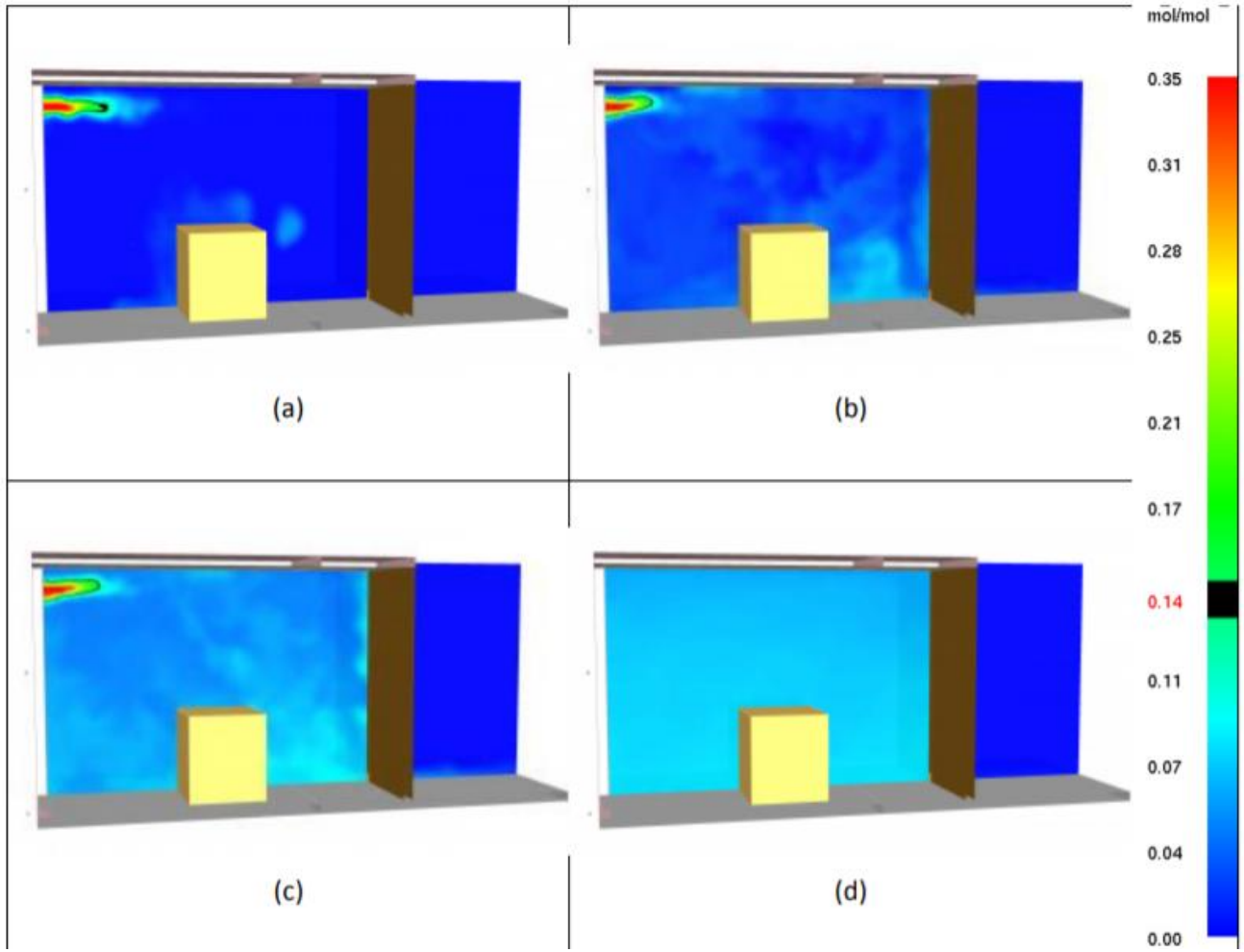
Mid-range with barrier with air circulation: Concentrations **below** LFL due to mixing

Mid-range with barrier with no circulation: **can result in** concentrations between LFL and UFL

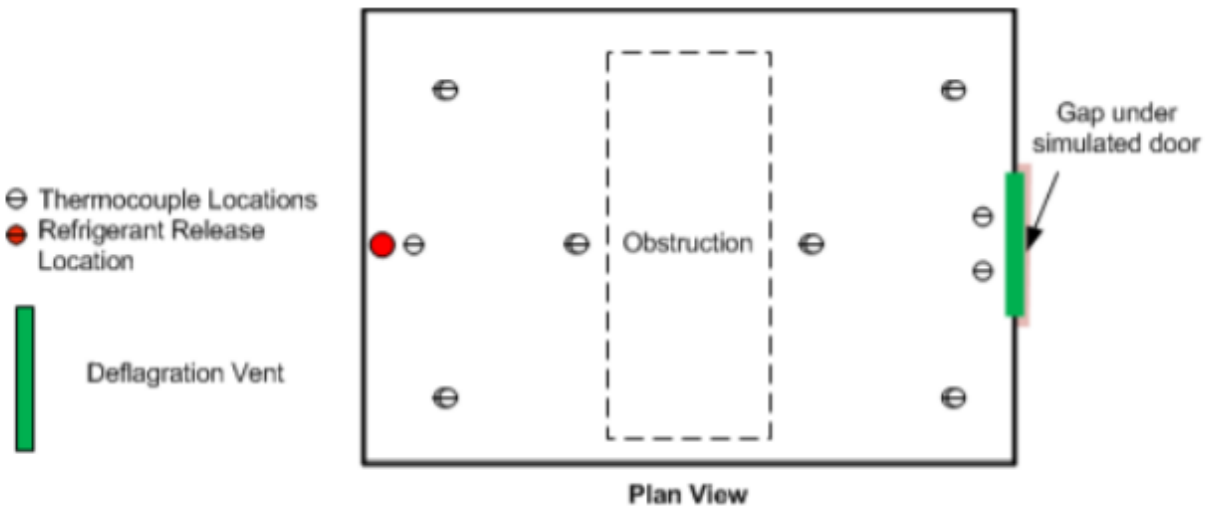
How safety standards were updated -

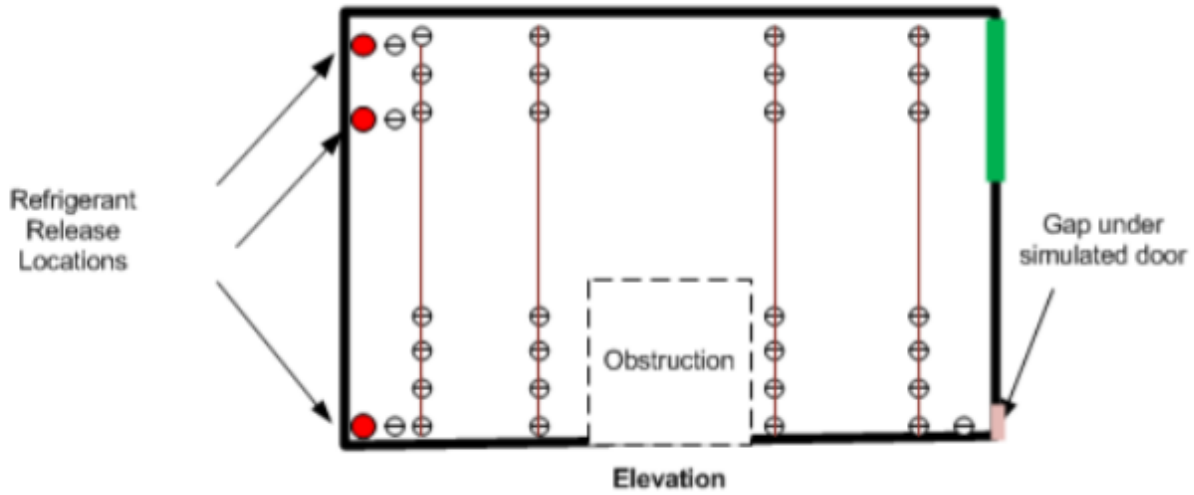
Charge size without sensor or ductwork requires use of gravity equation and mixing equations address these learnings

Simulation 1(Figure 2) shows that a high velocity (e.g., 100 g/s and 50 mm release opening) release results in a jet in the test room that causes turbulent mixing with the ambient air and yields relatively low concentrations of the refrigerants in the test room. The region of gas above LFL is confined to a small volume in front of the release location.



Release from 8 ft





Modeling showed that room setup required an obstruction to achieve concentration between LFL and UFL with no circulation/ mitigation

PTAC Unit in Motel Room

The PTAC tests were designed to emulate the release of refrigerant from the evaporator into a typical motel room sized 1660 ft³, 47.1 m³ with ignition devices representing those sources that could be expected to occur.

The refrigerant quantity released in the tests corresponds to proposed m1 size charge of (6 m3 × LFL kg/m3), where LFL is the lower flammable limit in kg/m3 from for the refrigerant used.

Nine tests were conducted for this scenario using R-32 and R-452B refrigerants. The ignition sources were tea candles (open flame) placed at floor level or electric arc sources which continually arced once energized at the various locations.

In some of the tests, the candle ignition source failed to either ignite or stay ignited. Refrigerant concentrations measured in the test room did not show values above the LFL and ignition did not occur. One test using R-452B resulted in a low energy ignition near the PTAC power cord plug lasting no more 3 seconds.

There was no secondary ignition of the cheesecloth for either refrigerant in this test. An additional test was added placing the electric arcs directly in front of the PTAC in the refrigerant discharge zone. This test resulted in ignition of the refrigerant.

IEC 60335-2-40 uses 50% LFL

IEC uses 50% LFL to initiate mitigation to account for:

- Furniture / obstacles
- Refrigerant density
- Safety factor

- IEC uses 50% LFL while UL uses 25% LFL in standards to initiate mitigation

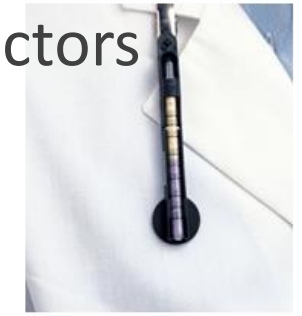
How do I know if there is a leak?

- There is a detector inside the equipment that will turn on fan at 25% LFL (or lower) and turn off cooilng, heating and electrostatic ignition sources
- The fan will be running and will not turn off.
- The unit will not cool or heat.
- Bottom line: No cooling or heating + fan running --> There may be a leak

Portable Gas or Oxygen detectors

What should the sensor detect? The technology is known and there are many detectors available including intrinsically safe ones.

- Significant leak required to reach LFL
  - • LFL (A2Ls) = 118,000 to 144,000 ppm
  - •LFL (Butane) = 18,000 ppm
- Sufficient O2- O2 Sensor
- Leak of fluorinated refrigerant- Hand-held leak detectors
  - ($200-$300) (10 to 1000 ppm)
- HF- Draeger tubes or HF monitors
  - ($200-$600) (10 to 1000 ppm)



Draeger Tubes

Crowcon HF Detector

Concentrations must be very high to reach LFL

Parameter	R-22	R-32	R-410A	R-452B	R-455A
Lower Flammability Limit (LFL, % volume)	no flame propagation	14.4	no flame propagation	11.9	11.8
(LFL, kg/m³) Sea Level		0.307		0.310	0.423
(LFL, kg/m³) 200 m (650 feet)		0.301		0.304	0.415
Upper Flammability Limit (UFL, % volume)	no flame propagation	29.3	no flame propagation	22.0	12.9
Refrigerant Concentration Limit (RCL, ppm v/v)	59,000	36,000	130,000	30,000	22,000
Laminar Burning Velocity (cm/s)	no flame propagation	6.7	no flame propagation	<4.0	<1.5
Composition (% mass)	100% R-22	100% R-32	50% R-32 50% R-125	67% R-32 26% R-1234yf 7% R-125	75.5% R-1234yf 21.5% R-32 3.0% R-744

AHRTI 9007-01

Sensing Leaks

Conditions at the end of refrigerant release

Release 25% LFL

60s after end of release (no ignition)

- An odorant (e.g. mercaptan) is added to some highly flammable fluids (e.g. natural gas) to provide a way to sense the presence of odorless, colorless gases with LFLs at or below 5% and very low ignition energies (natural gas <0.5 milliJoules) that have been involved in severe incidents. Odorant potential usage in AC is still under investigation.
- Large volumes of refrigerant must be released in order reach a flammable concentration (greater than 10%), so a high flow rate of refrigerant is needed:
  - Loud
  - Refrigerant cloud
  - Cold temperature as refrigerant is released

UL/AHRI Demonstration Project

- Review proposal through June 1
- 6 weeks from commencement to draft report
- 8 weeks to final report

Scenario	Test #1	Refrigerant	Scenario	Refrigerant
1	1	Baseline	Baseline 60 kW calorimeter measurements	None
	2	A1 #1	Discharge into open flame from various distances	R-410A
	3	A2L #1		R-32
	4	A2L #2		R-454B
	5	A1 #2		R-466A
2	6	Baseline	Flashover fire A1 room	None
	7	A1	Flashover fire with refrigerant line break	R-410A
	8	A2L #1		R-32
	9	A2L #2		R-454B
If Needed 3	10	A1	Flashover fire with fully charged system (no forced break)	R-410A
	11	A2L #1		R-32
	12	A2L #2		R-454B
4	13	Baseline	Combustibles fire in A1 Room	None
	14	A1	Forced line break during overhaul	R-410A
	15	A2L #1		R-32
	16	A2L #2		R-454B
5	17	Baseline	Kitchen gas fire in Room	None
	18	A1	Kitchen cooktop gas fire with refrigerant line break	R-410A
	19	A2L #1		R-32
	20	A2L #2		R-454B

AHRI Safe Refrigerant Transition Task Force

AHRI has formed a **Safe Transition Task Force** which has 7 working groups that are open to interested participants

Goals are to **evaluate end-to-end supply chain to enable the safe commercialization of low GWP refrigerants** in a timely manner and support the effort to reverse the **global warming trend**.

- Communications
- Safety Training
- Codes and Standards
- Transportation/Storage/Packaging/Handling
- Bulk Storage and Manufacturing Facilities
- Installation/Operation/Maintenance
- Recovery/Reclaim/Destruction

Establish structure to ensure continuous improvement

- Incident investigation
- Continuous maintenance standards
- Training upgrades

http://www.ahrinet.org/SafeRefrigerant

Contact one of the following people if interested in the Safe Refrigerant Transition Task Force

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Leverage learnings around the world

- **Widespread use of A2L refrigerants already in global HVAC&R industry** in European Union, Japan, India and Australia and auto industry (including US and Canada)