ASHRAE 1721-RP: Oil Return and Retention in Unitary Split System Gas Lines with HFC and HFO Refrigerants

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Agenda

- Project Background
- Test Setup
- Modifications
- Oil Injection
- Oil Retention Measurement Method
- Project Schedule

Project Background

Motivation

- The rising applications of variable speed and tandem compressors coupled with emerging refrigerant-oil combinations have brought about the importance of additional design parameters to help determine not only the line size but to also give values for oil retention for interconnecting gas lines of systems running vapor compression cycle.

Objectives

- Gain a better understanding with regard to oil retention of interconnecting gas lines used in air-conditioning systems.
- Develop a user-friendly modeling tool and engineering design guidelines for sizing refrigerant piping in unitary split systems.
- Collect data for a wide range of tests that considers existing and new refrigerant-lubricant combination, different orientation and geometry of refrigerant lines, varying refrigerant flow rates and with different concentrations of oil.

Project Background

Task Overview

Task 1: Literature Review

- Papers related to studies carried out in past have been reviewed and reported
- Various oil measurement techniques have been studied and reported

Task 2: Development of Test Matrix

- Preliminary test matrix has been prepared and reported which considers
- PMS has agreed to initiate testing with R134a with POE
- Further oils will be selected for the remaining refrigerants based on the results obtained from R134a and POE

Task 3: Design and Construction of Experimental Setup

- Construction of the test setup is completed
- Results of shakedown test with only refrigerant will be presented in the current meeting

Task 4: Collect R134a/POE Baseline Data

- Baseline data will be collected in the upcoming quarter

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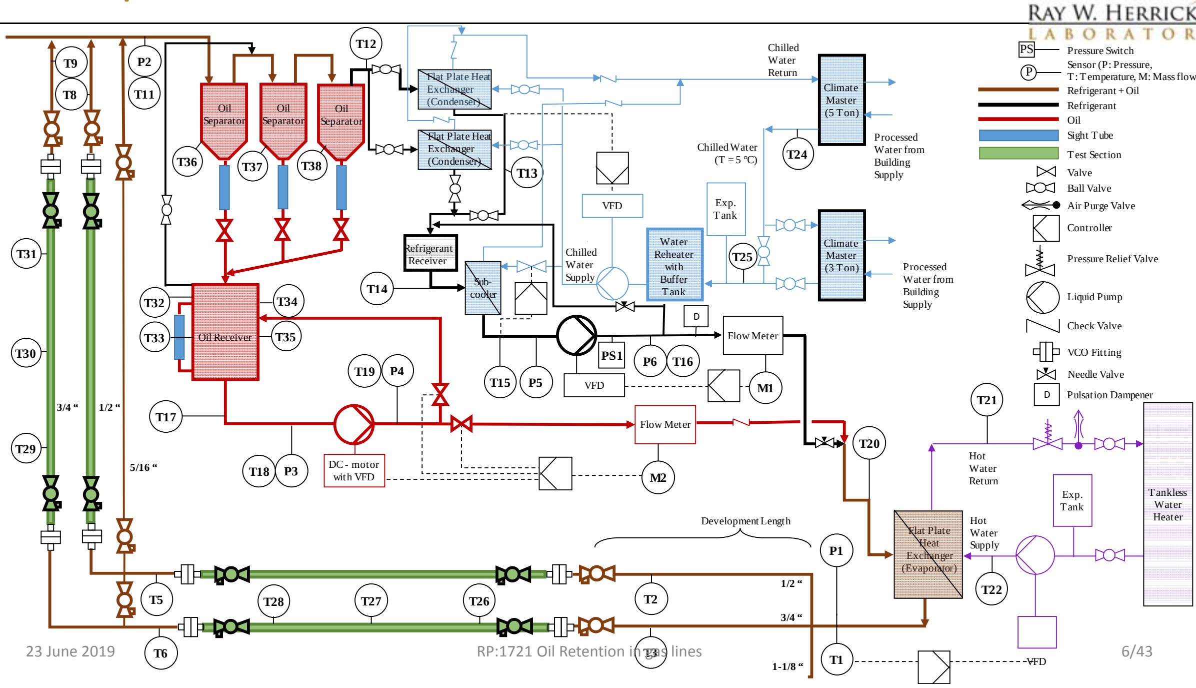
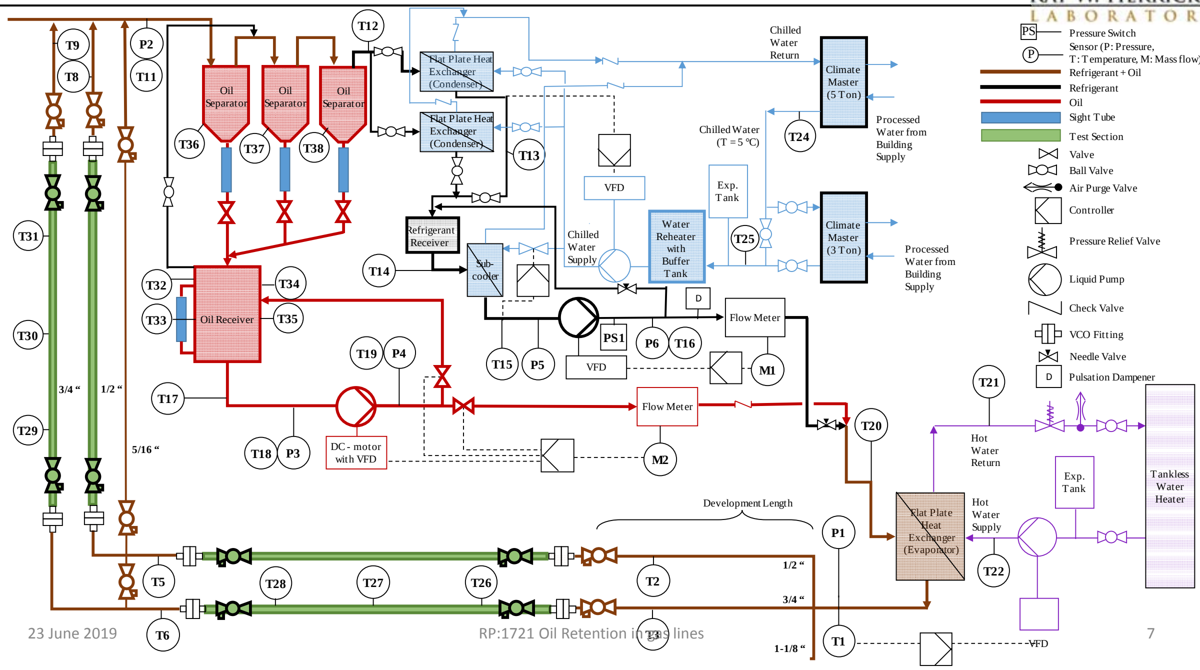
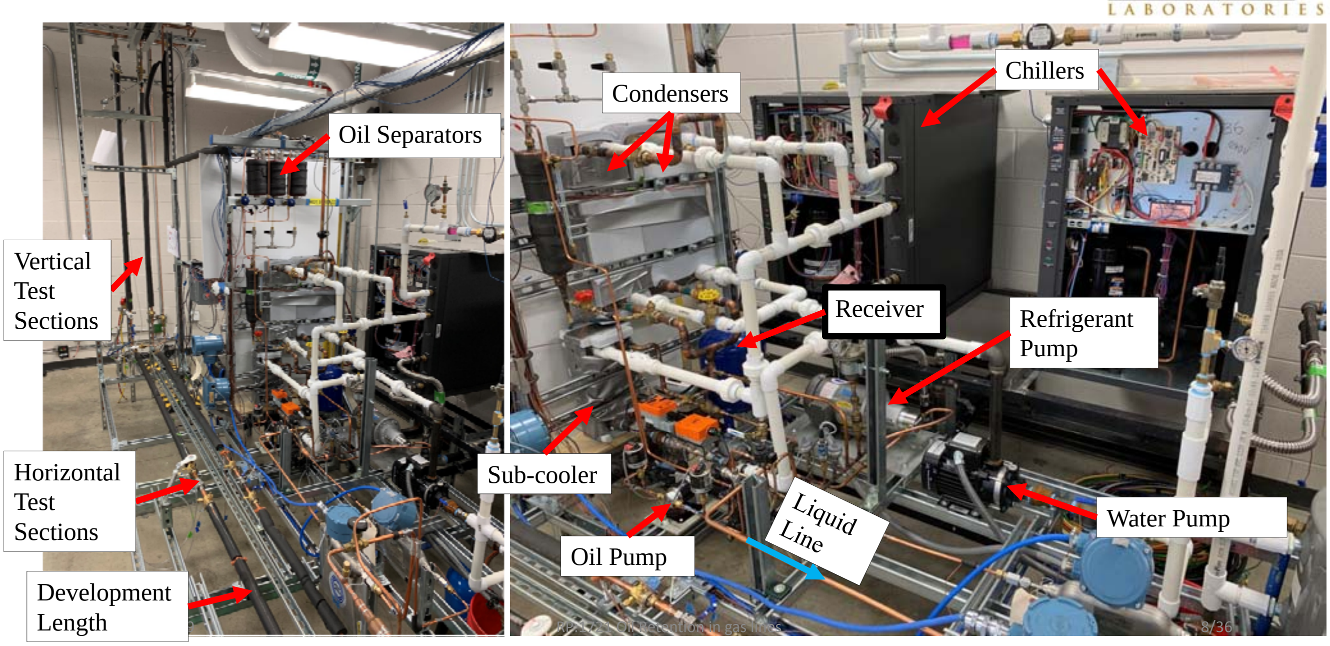
Test Setup



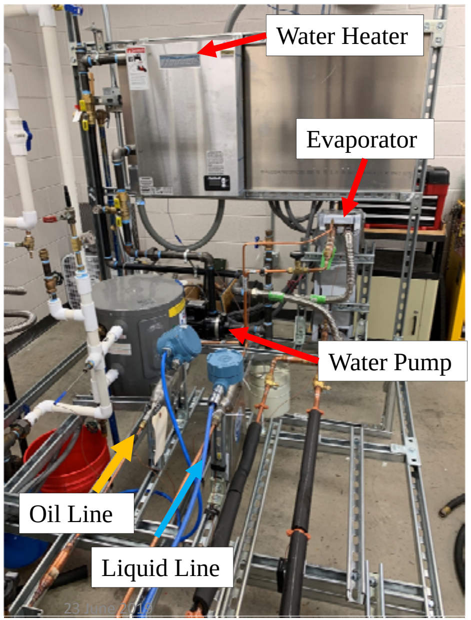
Test Setup

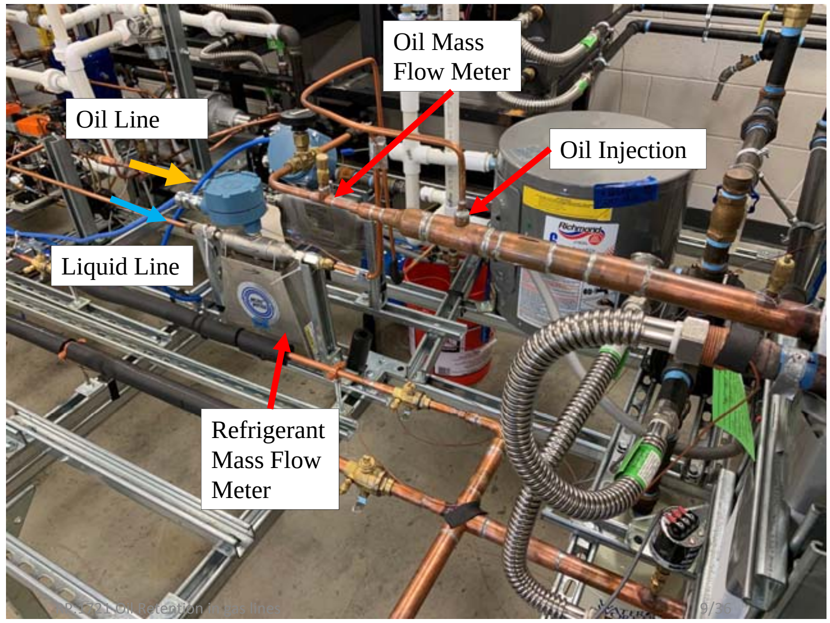


Test Setup



Test Setup





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Test Matrix

Sr. No.	Refrigerant	Oil	Viscosity [cSt]	Nominal Line Diameter [mm]	Oil Circulation Rate [%]	Mass Flow Rate	Test Section Saturation Temperature [C]	Test Section Inlet Temperature [C]
1 (Baseline)	R134a	POE	32cSt	19.05	0.5, 3, 5	1/3, 1, 2 and 3x of Jacob's Limit	10	20
							40	64
		POE	68cSt	19.05	0.5, 3, 5	1/3, 1, 2 and 3x of Jacob's Limit	10	20
							40	64
		POE	100cSt	19.05	0.5, 3, 5	1/3, 1, 2 and 3x of Jacob's Limit	10	20
							40	64
		POE	170cSt	19.05	0.5, 3, 5	1/3, 1, 2 and 3x of Jacob's Limit	10	20
							40	64
2	R410A	POE	32cSt	12.70, 19.05,28.57	0.5, 3, 5	1/3, 1, and 2 of Jacob's Limit	10	20
						1/3, 1, 2 and 3x of Jacob's Limit	40	75
		POE	68cSt	12.70, 19.05,28.57	0.5, 3, 5	1/3, 1, and 2 of Jacob's Limit	10	20
						1/3, 1, 2 and 3x of Jacob's Limit	40	75
		PAG/PVE ?	?	12.70, 19.05,28.57	0.5,3,5	1/3, 1, and 2 of Jacob's Limit	10	20
						1/3, 1, 2 and 3x of Jacob's Limit	40	75
		AB	?	12.70, 19.05,28.57	0.5, 3, 5	1/3, 1, and 2 of Jacob's Limit	10	20
						1/3, 1, 2 and 3x of Jacob's Limit	40	75

Refrigerant Only : Suction Line

Suction Line Test (Previous)

Sr. No.	Refrigerant - Lubricant	Nominal Line Diameter [mm]	Ref. Mass Flow Rate [kg/hr]	Oil Circulation Rate [kg/hr]	Test Section Saturation Temperature [C]	Test Section Inlet Temperature [C]
1 (Baseline)	R134a - POE 32	19.05	11	0.055	10	20
				0.33	10	20
				0.55	10	20
			33	0.165	10	20
				0.99	10	20
				1.65	10	20
			66	0.33	10	20
				1.98	10	20
				3.3	10	20
			100	0.5	~~10~~ 20	~~20~~ 30
				3	~~10~~ 20	~~20~~ 30
				5	~~10~~ 20	~~20~~ 30

- Can Achieve
- Partially Achieve
- Cannot Achieve

Refrigerant Only : Suction Line

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Suction Line Test (Current)

Sr. No.	Refrigerant - Lubricant	Nominal Line Diameter [mm]	Ref. Mass Flow Rate [kg/hr]	Oil Circulation Rate [kg/hr]	Test Section Saturation Temperature [C]	Test Section Inlet Temperature [C]
1 (Baseline)	R134a - POE 32	19.05	11	0.055	10	20
				0.33	10	20
				0.55	10	20
			33	0.165	10	20
				0.99	10	20
				1.65	10	20
			66	0.33	10	20
				1.98	10	20
				3.3	10	20
			100	0.5	~~10~~ 20	~~20~~ 30
				3	~~10~~ 20	~~20~~ 30
				5	~~10~~ 20	~~20~~ 30

Can Achieve

Partially Achieve

-Added bypass valve on the refrigeration loop

Refrigerant Only : Suction Line

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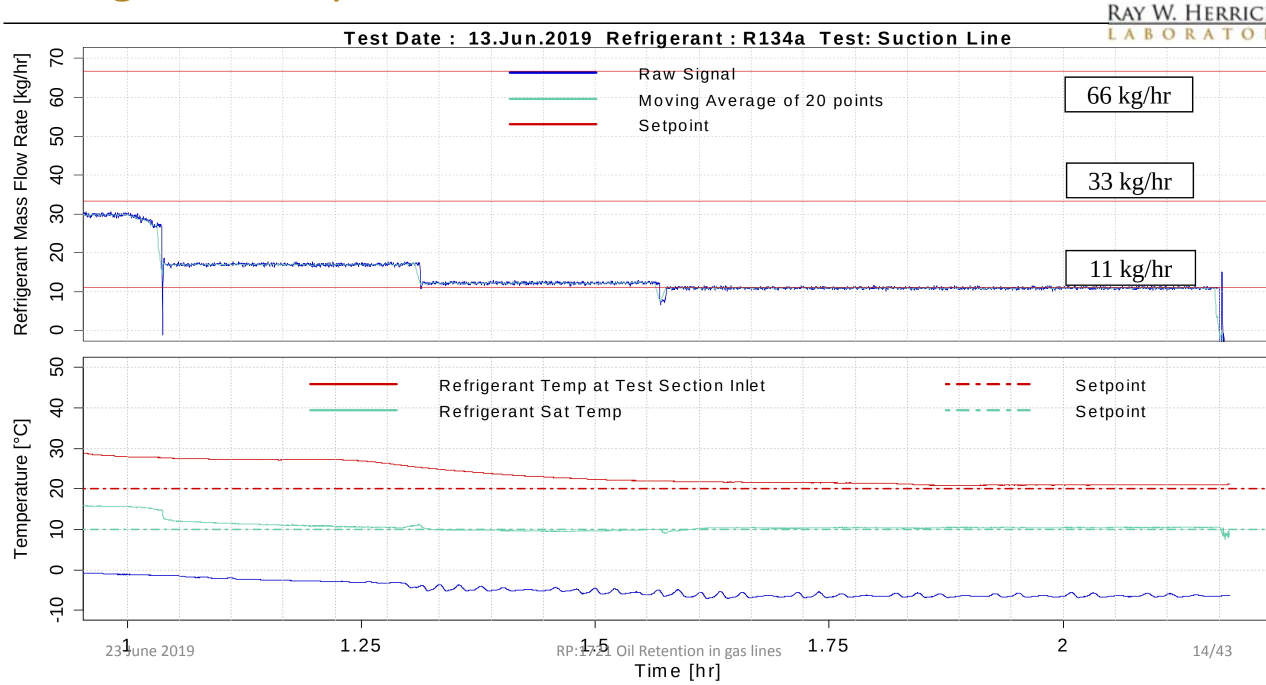
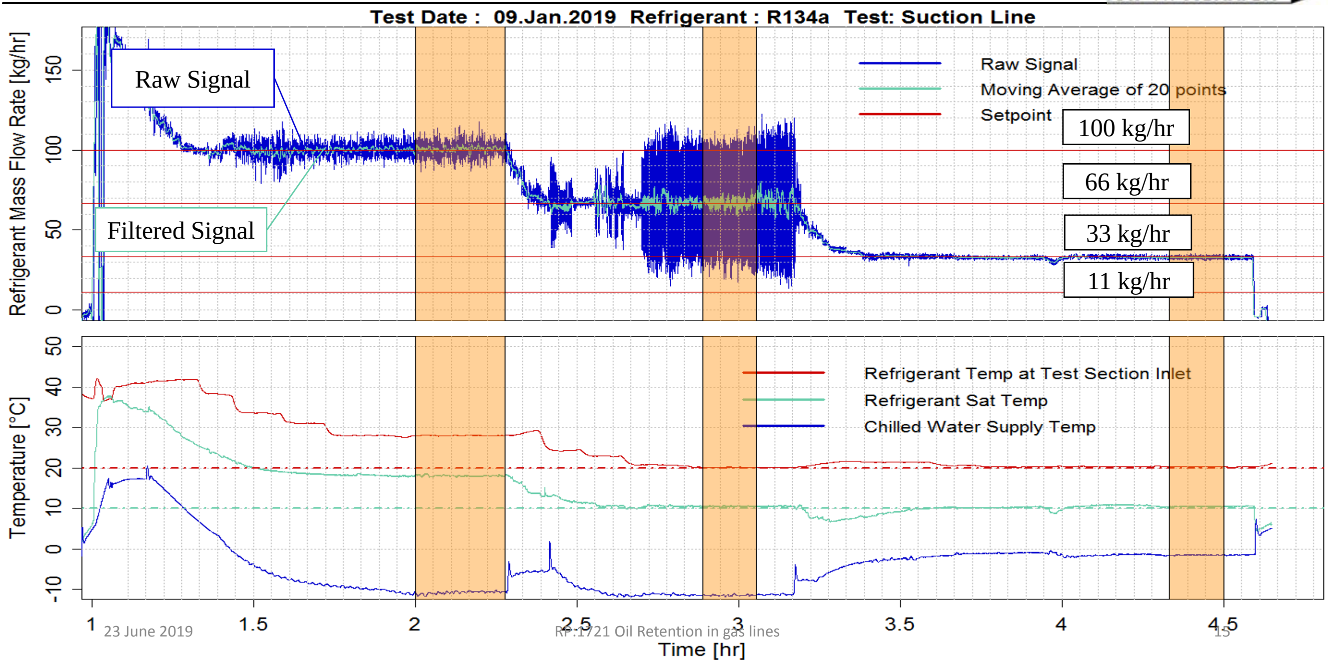
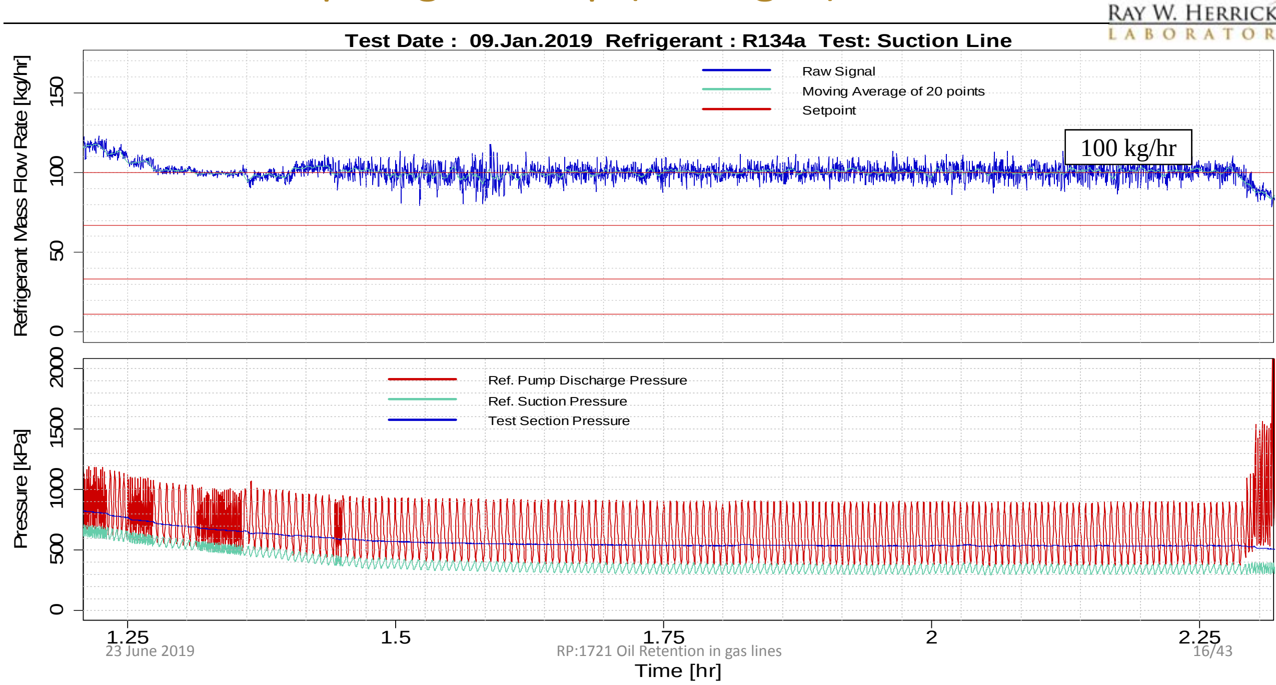


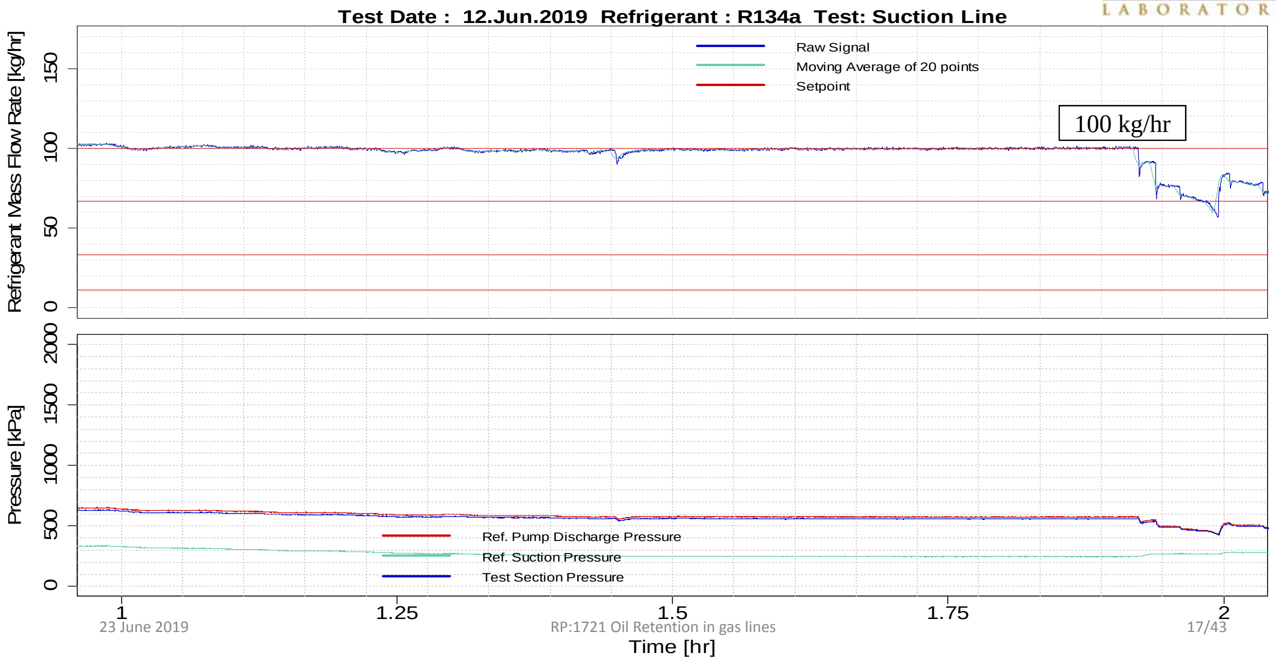
Pulsation – Refrigerant Pump



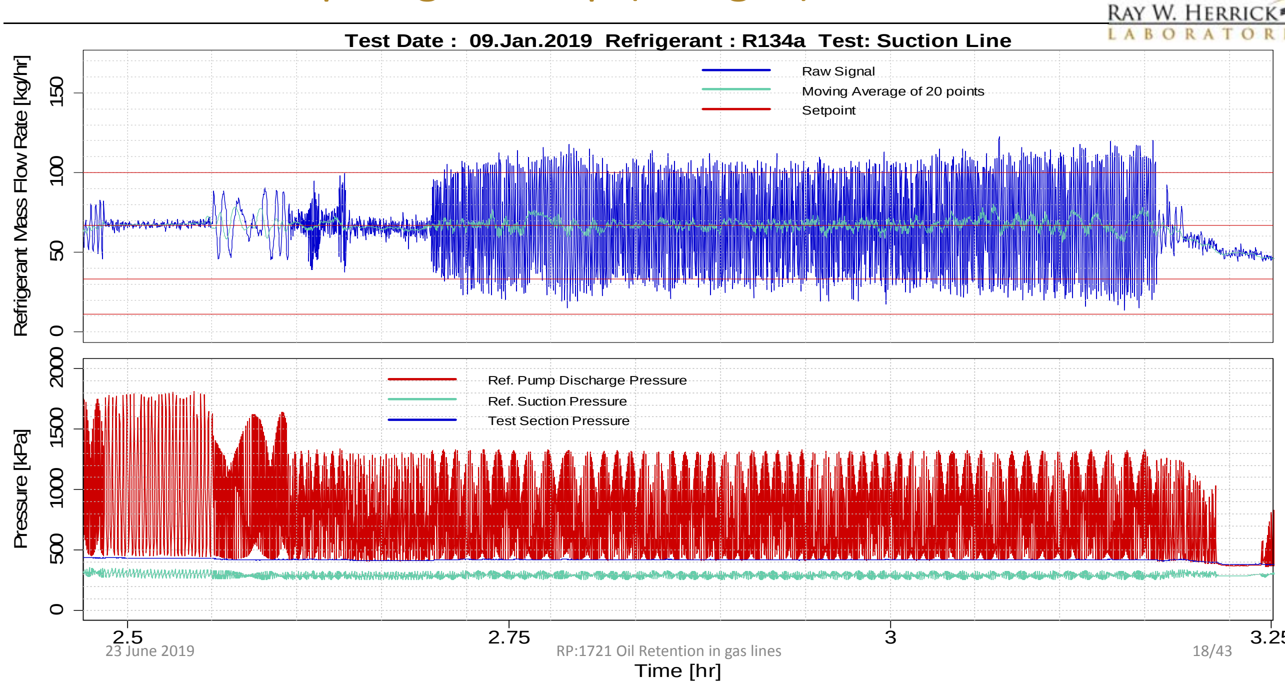
Pulsation – Diaphragm Pump (100 kg/h)



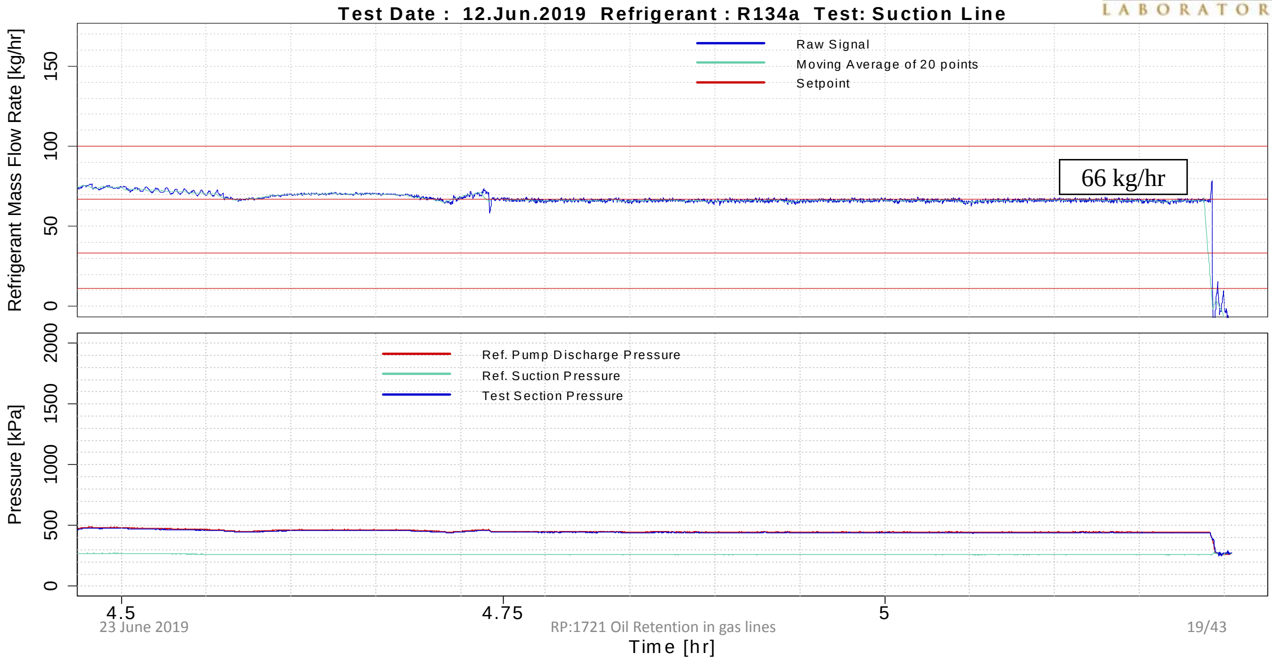
Pulsation – Gear Pump (100 kg/h)



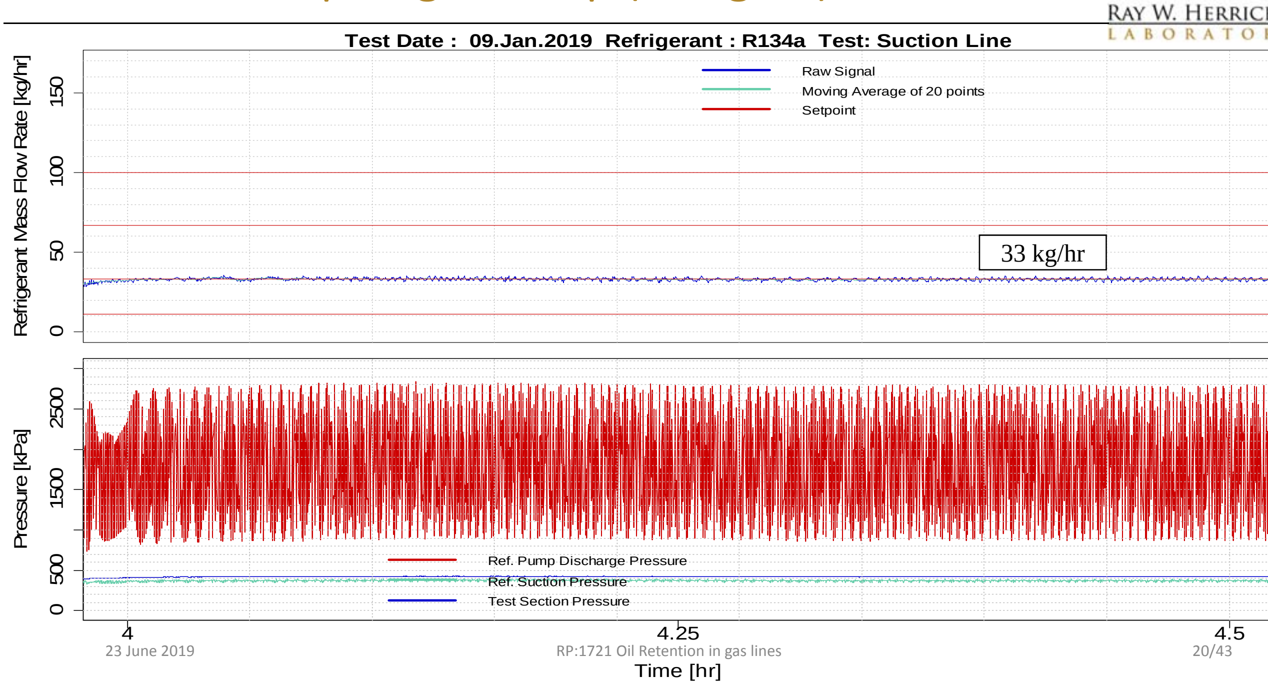
Pulsation – Diaphragm Pump (66 kg/h)



Pulsation – Gear Pump (66 kg/h)



Pulsation – Diaphragm Pump (33 kg/hr)



Pulsation – Gear Pump (33 kg/hr)

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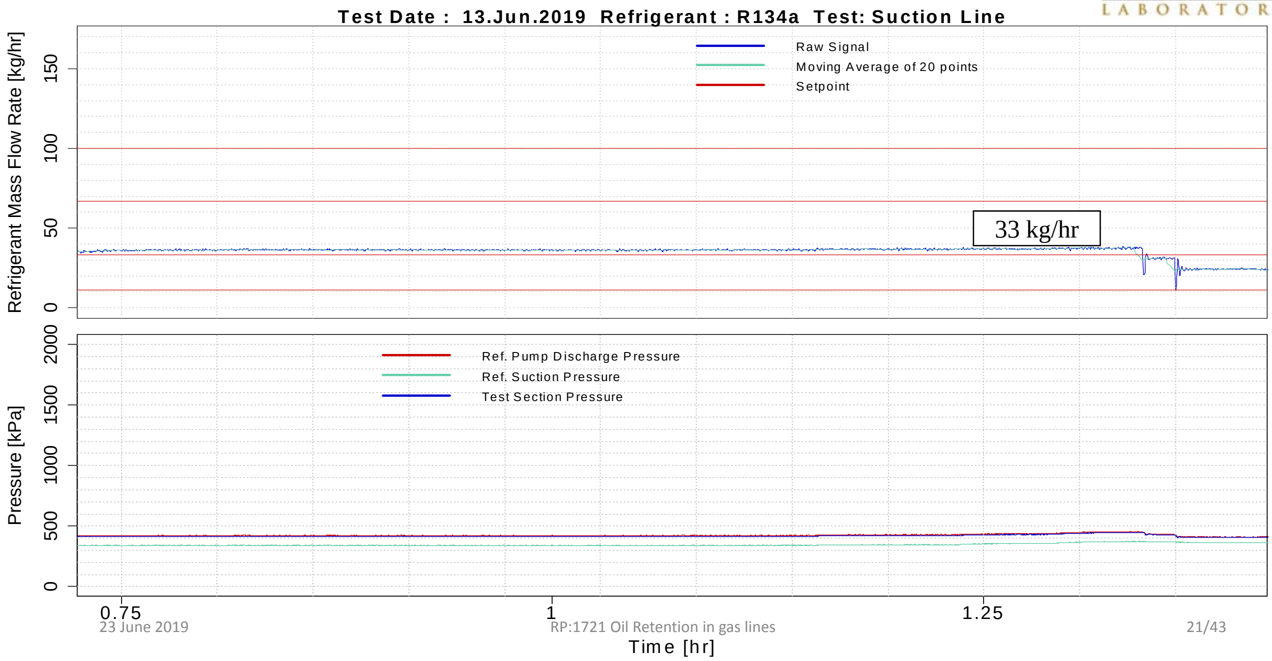

Liquid Refrigerant in Oil Separator

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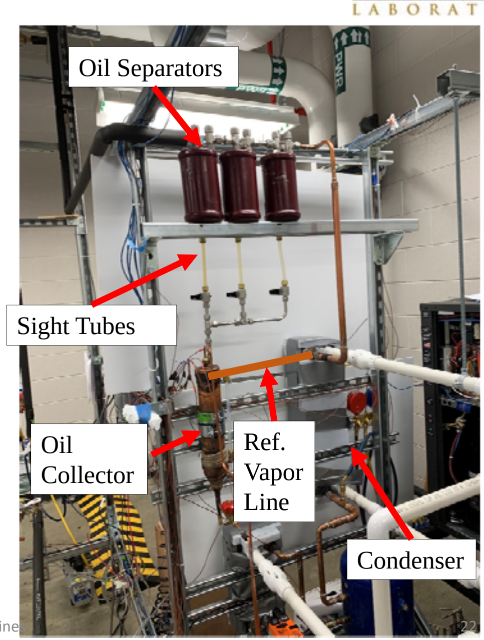
Problem

- Liquid Refrigerant getting condensed in the oil separator especially for the discharge line test

Solution

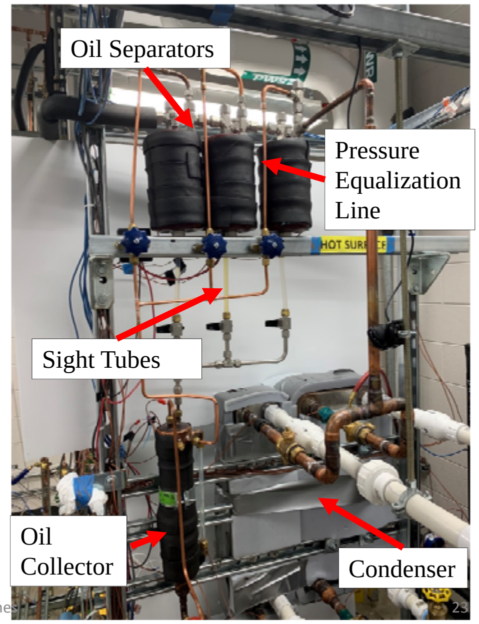
- Insulate the vapor line between the vertical test section and the oil separators
- Add a heater in the oil collector and maintain a temperature 10K > Sat. Temperature of the system to ensure all the refrigerant is evaporated
- If needed, connect the oil collector to the condenser inlet with a check valve



Liquid Refrigerant in Oil Separator

Solution

- Insulated the vapor line between the vertical test section and the oil separators
- Added a PID controlled heater along with thermocouples in the oil collector
- We maintain a temperature 10K > Sat. Temperature of the system to ensure all the refrigerant is evaporated
- Added PID controlled heater along with thermocouple in oil collector as well
- Added pressure equalization line between the oil separator shell and the oil collector for the oil to flow under gravity



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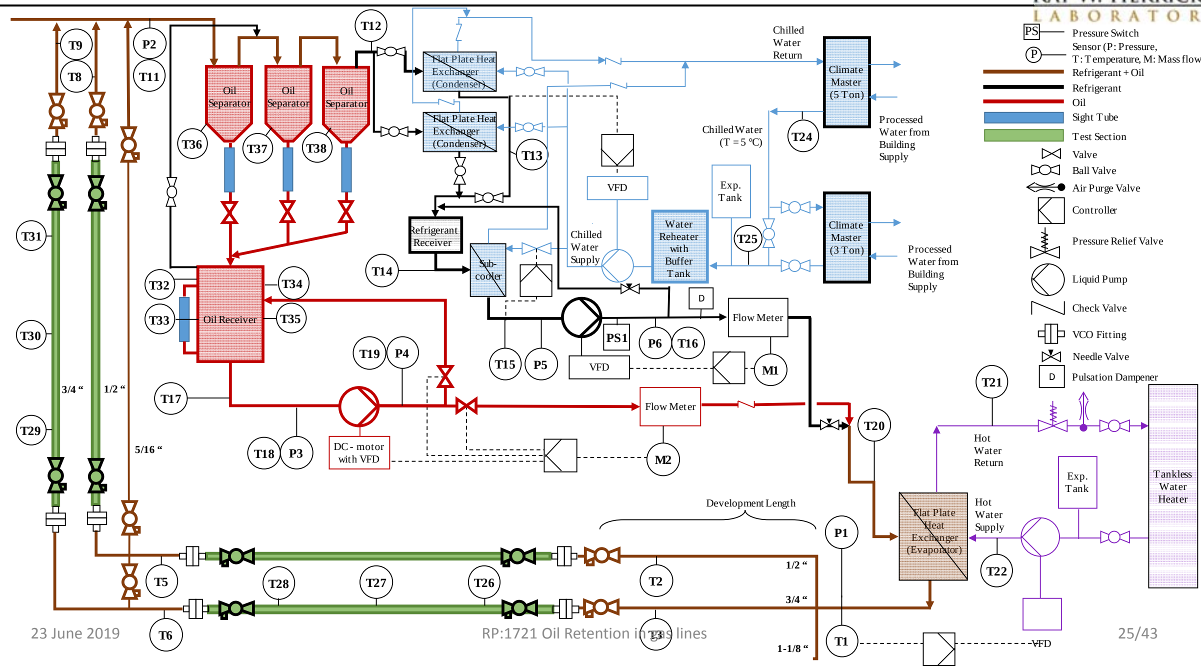
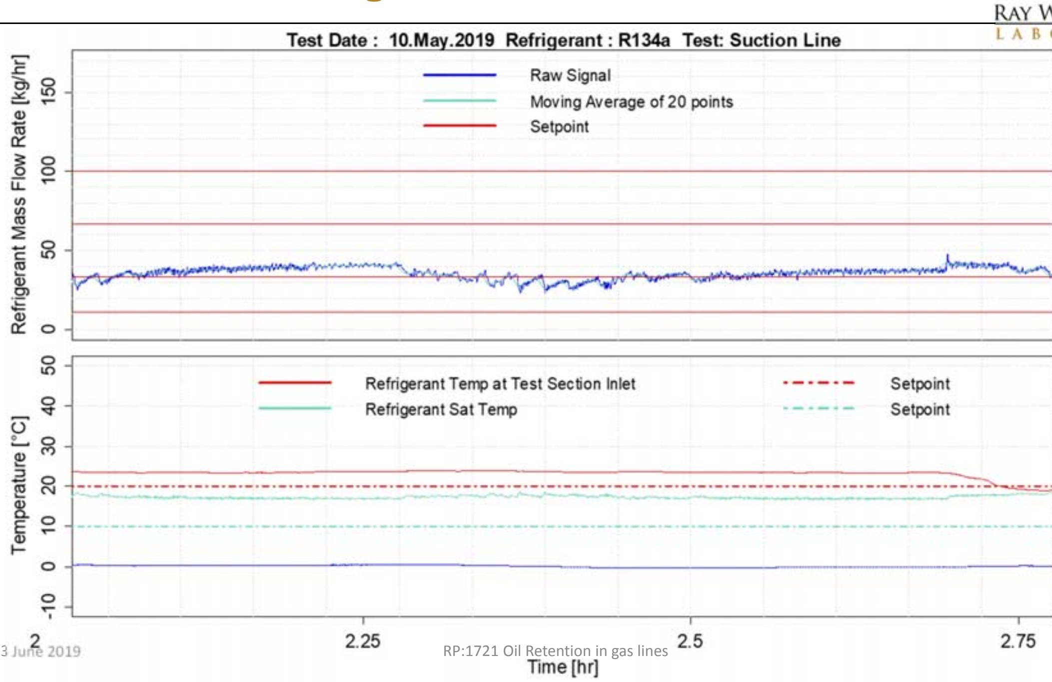
Oil Injection



Oil Return Issue – 33 kg/hr



Oil Return Issue – 33 kg/hr

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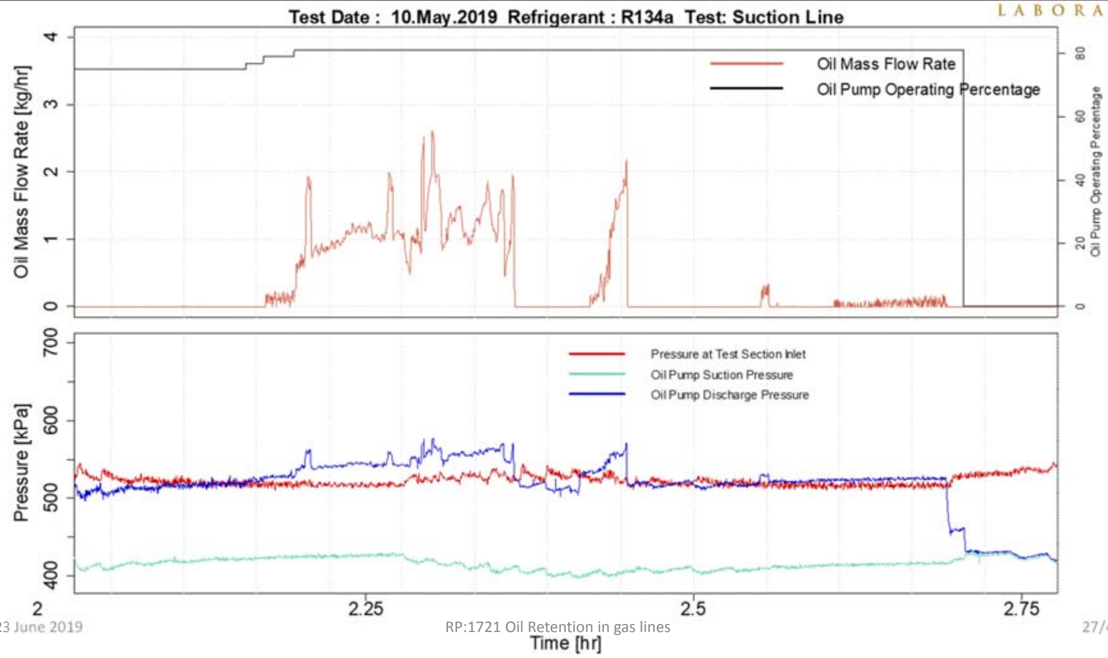

Oil Return Solution

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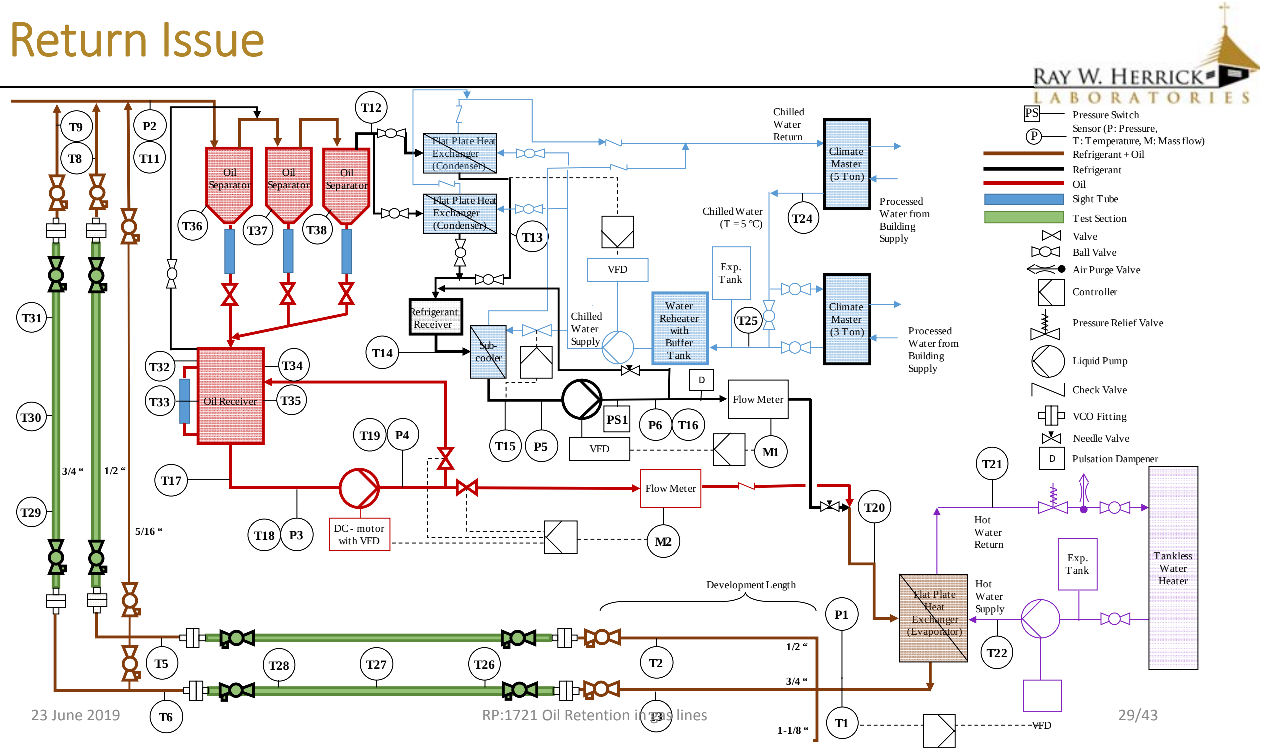
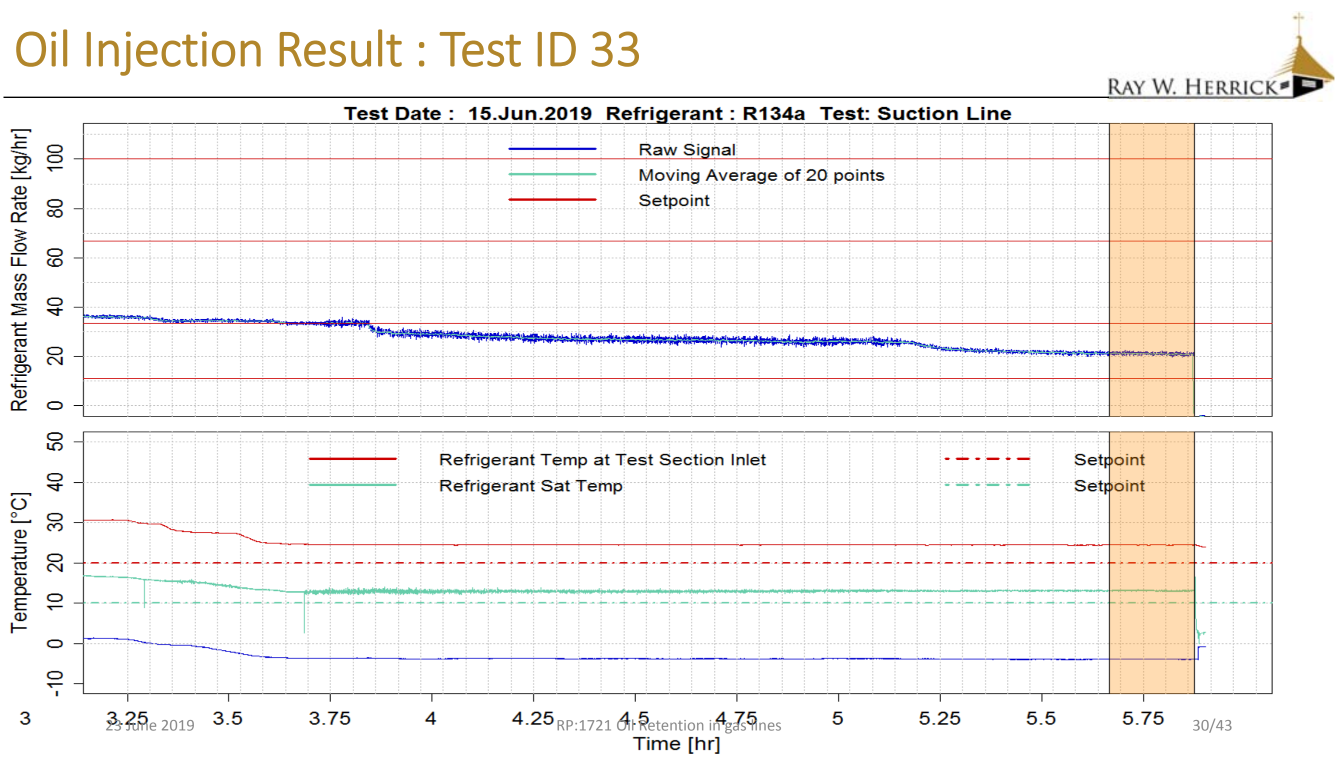
Test Section	Refrigerant Mass Flow Rate [kg/h]	Test Section Inside Diameter [mm]	Mass Flux [kg/s-m^2]	Jacob's Limit	Nominal Pipe Size
Horizontal	33	16.9	40.8	1	3/4"
Vertical	33	10.9	97.8	2.4x	1/2"
Horizontal	11	16.9	13.6	0.3x	3/4"
Vertical	11	6.3	98.0	2.4x	5/16"

Oil Return Issue



Oil Injection Result : Test ID 33



Oil Injection Result : Test ID 33

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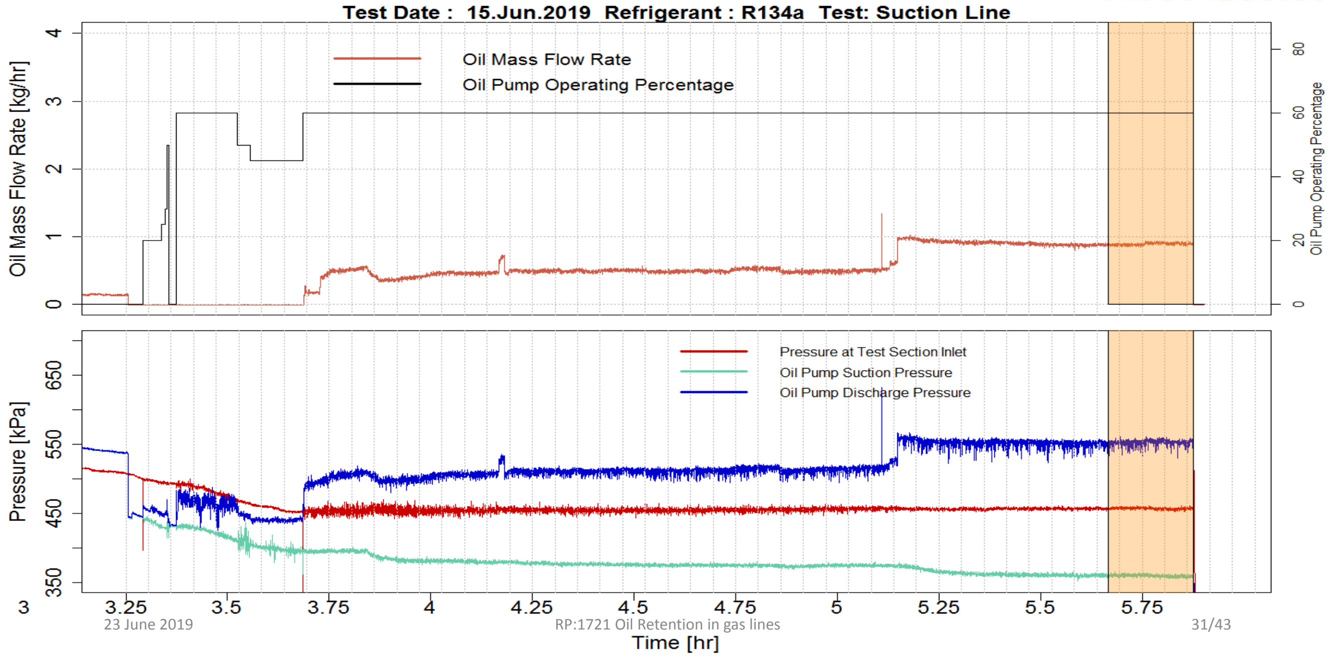

Oil Injection Result : Test ID 33

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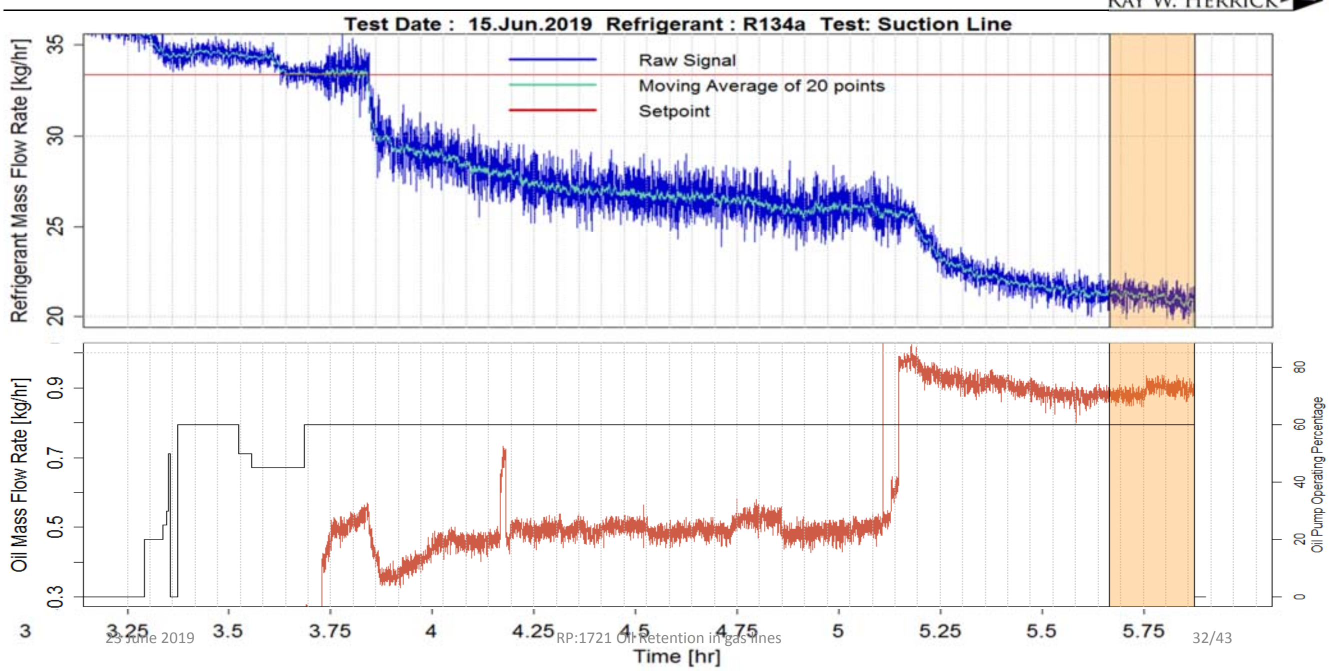

Oil Injection Result : Test ID 34

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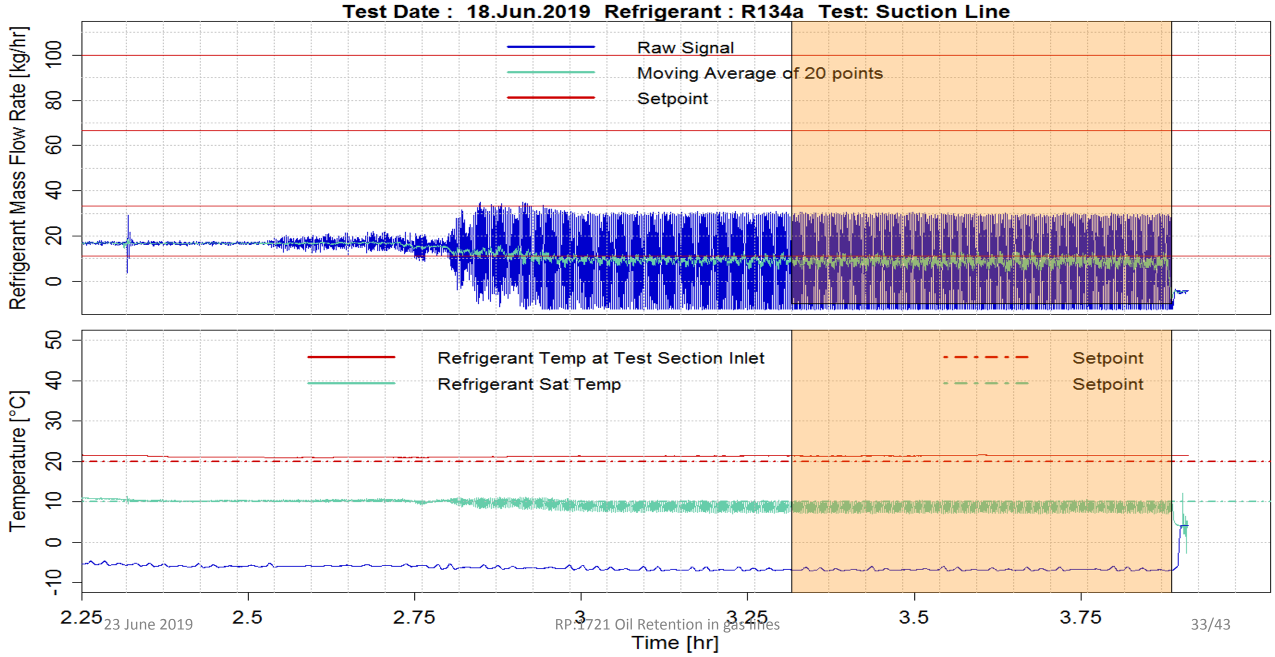

Oil Injection Result : Test ID 34

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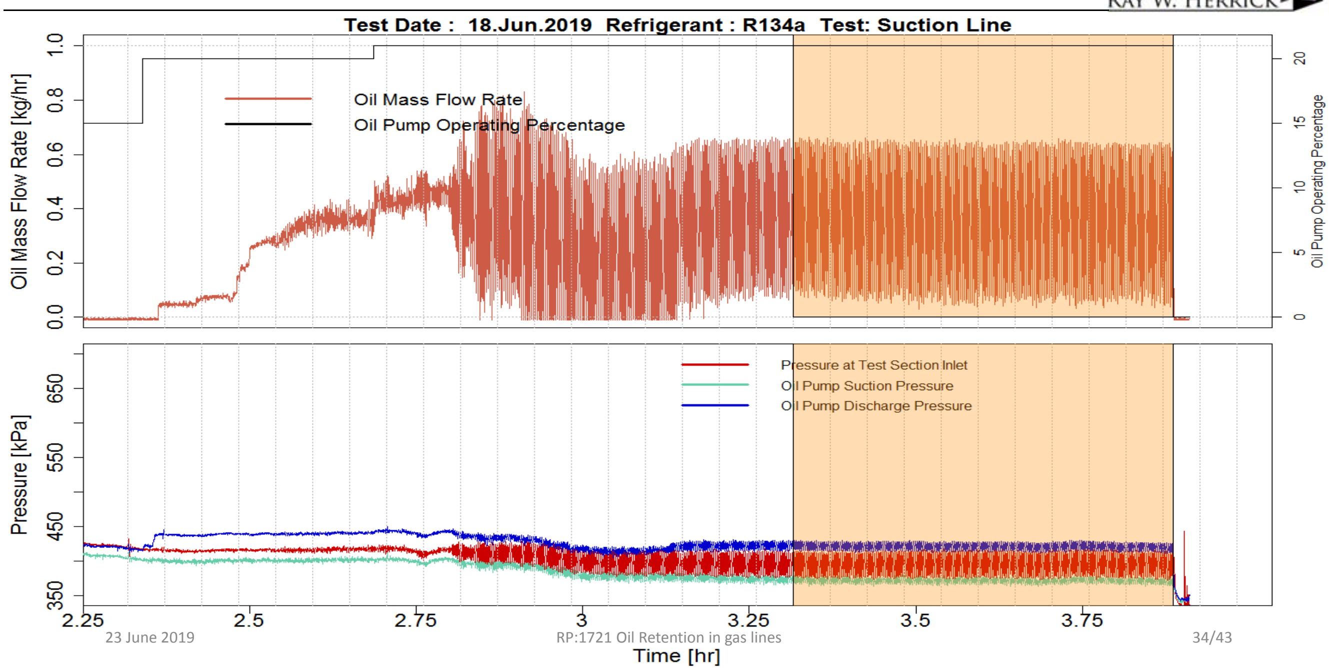
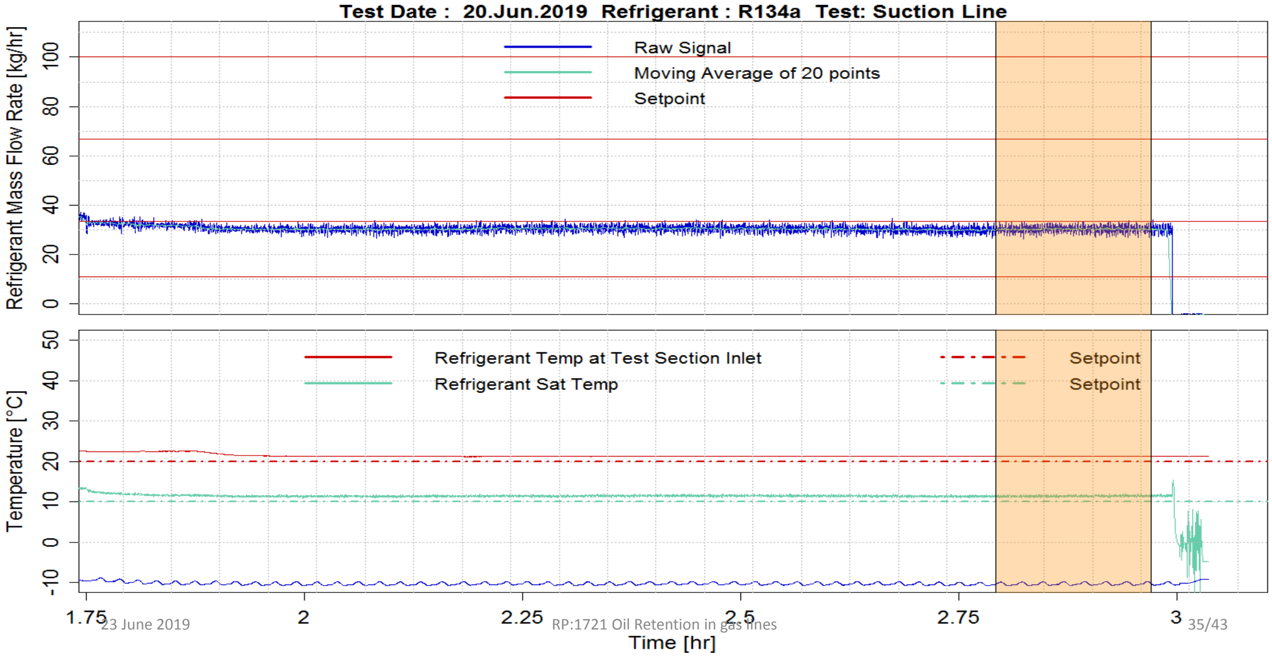
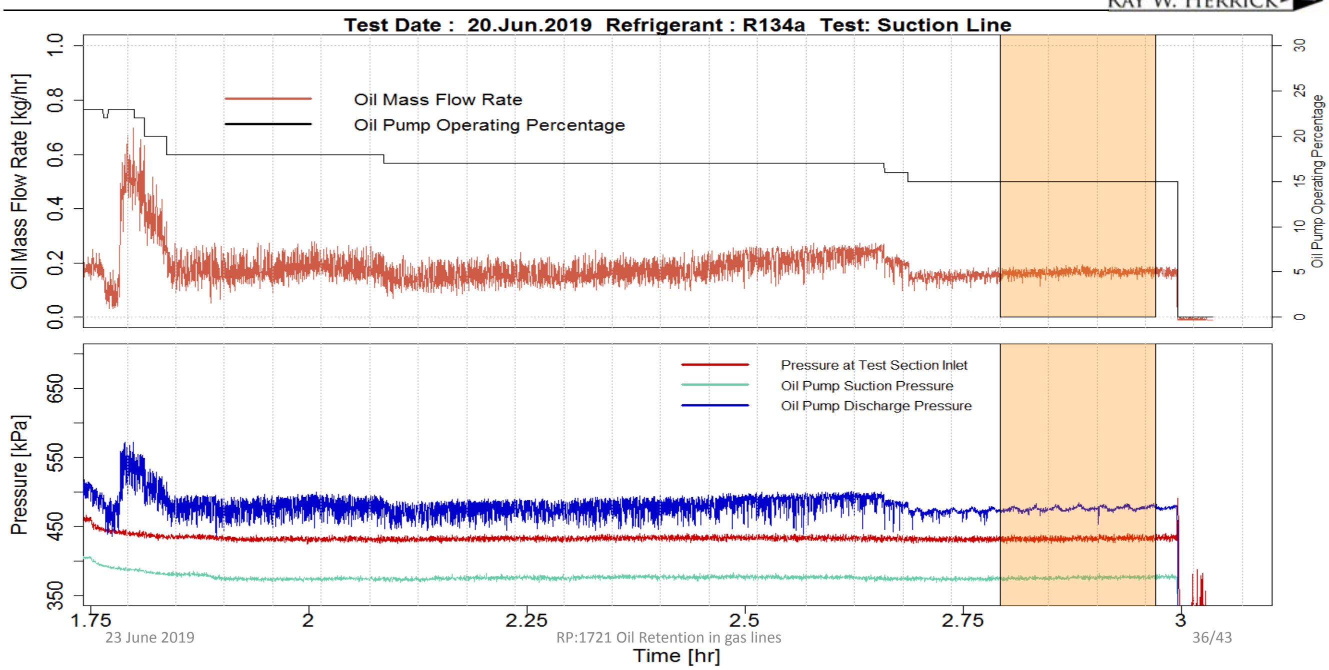


Oil Injection Result : Test ID 35



Oil Injection Result : Test ID 35



Oil Injection Result

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Sr.	Description	TestID 33	TestID 34	TestID 35	Unit
1	Refrigerant	R134a	R134a	R134a	
2	Oil	POE-32	POE-32	POE-32	
3	Test Mode	Suction	Suction	Suction	
4	Horiztal Pipe Dia	16.9	16.9	16.9	mm
5	Vertical Pipe Dia	10.9	6.3	10.9	mm
6	Ref Flow Rate	21.1	8.76	30.31	kg/h
7	Oil Flow Rate	0.89	0.36	0.16	kg/h
8	Ref Mass Flux - Horizontal	26.07	10.83	37.46	kg/m2-s
9	Ref Mass Flux - Vertical	62.53	78.09	89.86	kg/m2-s
10	OCR	4.23	4.08	0.54	%
11	**Oil Retention - Horizontal**	**10.49**	**11.63**	**4.27**	**g/m**

Ankit Sethi & Pega Hrnjak (2014) Oil retention and pressure drop of R1234yf and R134a with POE ISO 32 in suction lines, HVAC&R Research, 20:6, 703-720

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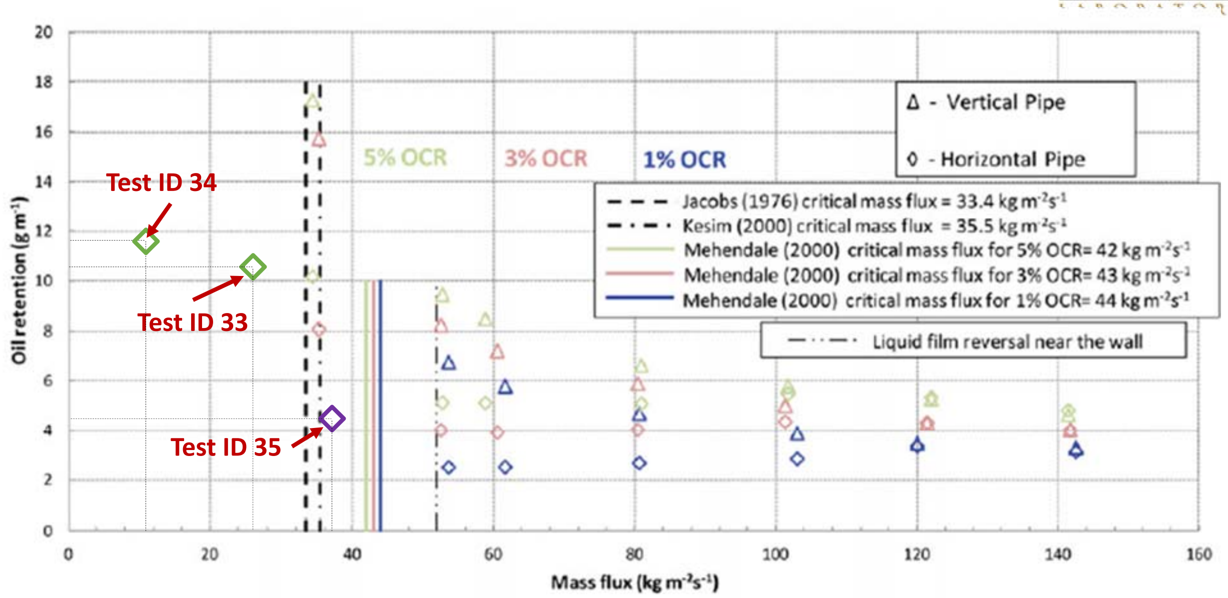

Fig. 9. Oil retention as a function of mass flux for three OCRs for R134a/POE 32 in 10.2-mm inside-diameter pipe.

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Oil Retention Measurement

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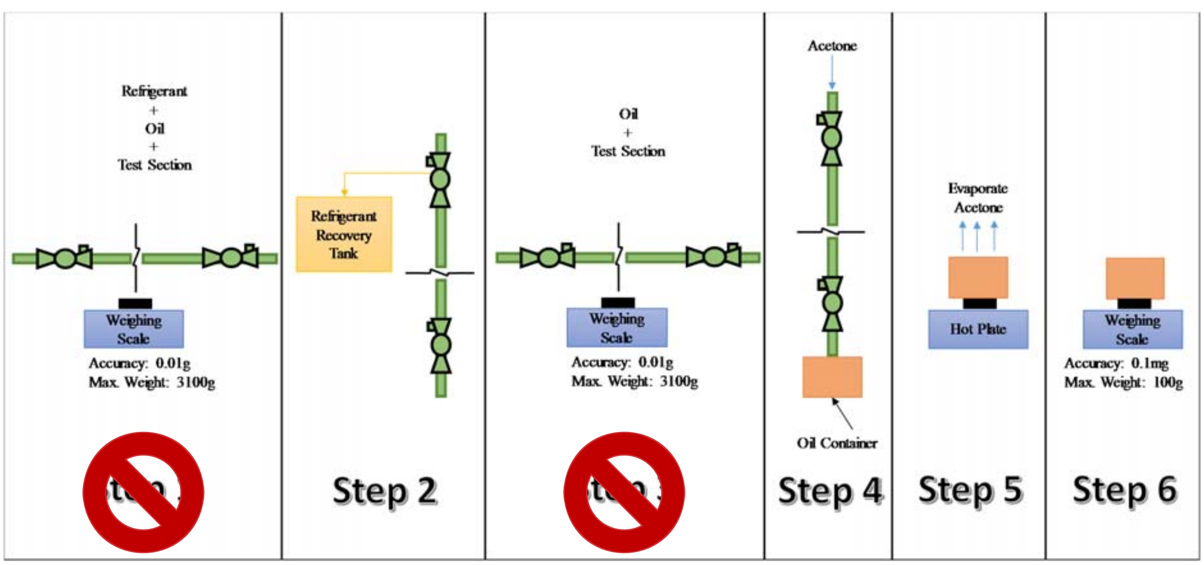

Agenda

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- Project Background
- Test Setup
- Test Matrix
- Shakedown Test Results (Oil Free)
- Oil Retention Measurement Method
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Schedule

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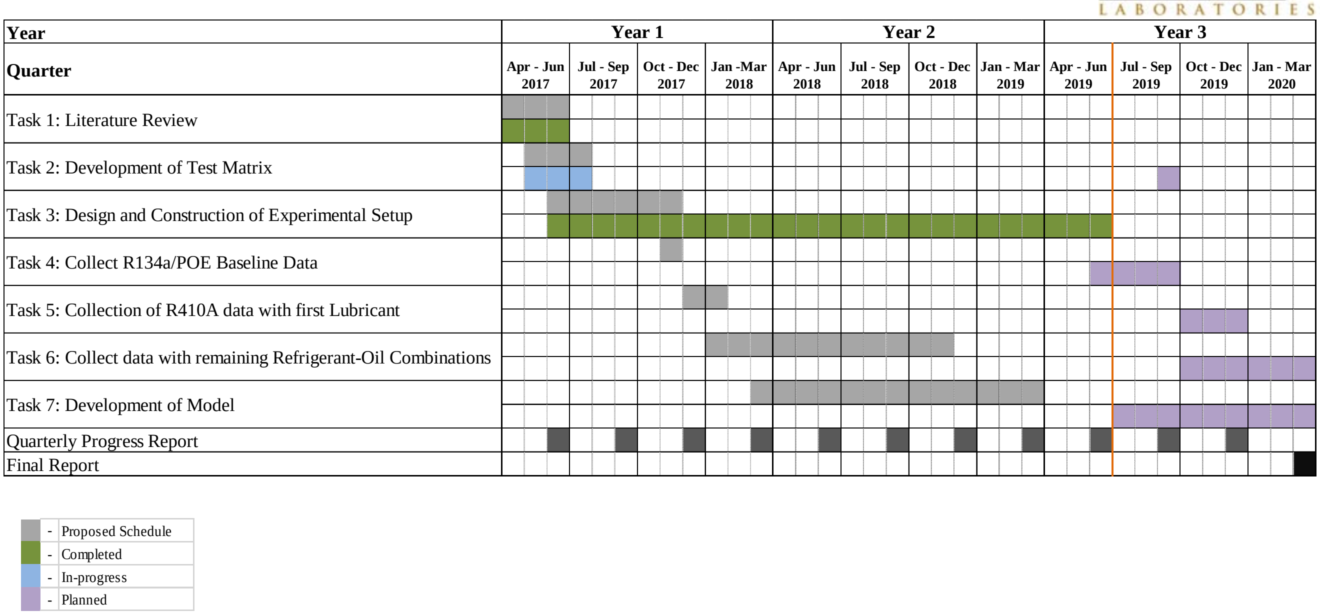

Thank You.