STUDY OF LUBRICANT CIRCULATION IN HVAC SYSTEMS

Volume II - Compilation of Program Test Data

Final Technical Report
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Study of Lubricant Circulation in HVAC Systems

Volume II - Compilation of Program Test Data

SUMMARY

This volume contains all of the program test data essentially as taken from the laboratory dynamic test facility during the sequence of runs.

For the readers' convenience Table 3.1 from Volume I of the report, is included to describe the refrigerant/lubricant test series (six) and the actual chronological test run number. Figures 2.1 and 2.2 from Volume I are also included here for reference.

In the body of this Volume, each of the test series is presented separately, again for the convenience of the reader.

Volume I contains a complete description of the program scope, objective, test results summary, conclusions, description of test facility and recommendations for future effort.


**Study of Lubricant Circulation in HVAC Systems**

**Volume II - Compilation of Program Test Data**

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* additional oil injected into compressor
† no test run
Figure 2.1. Oil Circulation Program Dynamic Test Facility - Cooling Mode
Figure 2.2. Oil Circulation Program Dynamic Test Facility - Heating Mode
Refrigerant/Lubricant Test Series

R22 - Suniso 3GS
Heat Pump R22-Suniso 3GS Oil Circulation Tests (35&36)

Cooling & Heating Modes - No Oil Injection

System Temperatures

System turned on

System turned off

Changed to heating
Heat Pump R22-Suniso 3GS Oil Circulation Tests (35&36)

Cooling & Heating Modes - No Oil Injection

System Pressures

Pressure (psig)

System turned on

System turned off

Changed to Heating

Hours
Heat Pump R22-Suniso 3GS Oil Circulation Tests (35&36)

Cooling & Heating Modes - No Oil Injection

Air Side Temperatures

Temperature (°F)

System turned on

System turned off

Temperature (°F)

Hours

TIE1
TIE2
TII1
TII2
TOE1
TOE2
TOII
TOI2
Heat Pump R22-Suniso 3GS Oil Circulation Tests (37-39)

System Temperatures

Temperature (°F)

Hours

TS1  TS2  TS3  TS4  TS5  TS6  TS7  TS8
Heat Pump R22-Suniso 3GS Oil Circulation Tests (37-39)

Air Side Temperatures

Temperature (°F)

Hours

120
100
80
60
40
20
0

System turned off

TOE

TOI

TII

TIE

TIE1  TIE2  TII1  TII2  TOE1  TOE2  TOI1  TOI2
Heat Pump R22-Suniso 3GS Oil Circulation Tests (37-39)
Heating Mode - Oil Injection

Oil Flows

Time (hrs)

Oil Concentration (%)

Vapor Velocity (ft/min)

Defrost
2 valves open
1 valve open
3 valves open
4 valves open
1 valve open
3 valves open
4 valves open
1 valve open
2 valves open
3 valves open
4 valves open

System turned off
Heat Pump R22-Suniso 3GS Oil Circulation Tests (40-42)

Heating (No Oil Injection) & Cooling (Oil Injection) Mode

System Pressures

Pressure (psig)

Hours

PS1
PS2
PS3
PS4
PS5
PS6

System turned on
System turned off
Changed to Heating then back to Cooling
Heat Pump R22-Suniso 3GS Oil Circulation Tests (40-42)
Heating (No Oil Injection) & Cooling (Oil Injection) Mode

SLO 2/26/96
Refrigerant/Lubricant Test Series

R407C - Suniso 3GS
Heat Pump R407C-Suniso 3GS Oil Circulation Test (43)

Cooling Mode - No Oil Injection

System Pressures

Pressure (psig)

System turned on

Added 1# Refrigerant

System turned off

PS1
PS2
PS3
PS4
PS5
PS6

Hours

0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5
Heat Pump R407C-Suniso 3GS Oil Circulation Test (43)

Cooling Mode - No Oil Injection

SLO 2/28/96

[Graph showing data related to mass flow rate and vapor velocity over time. The graph includes annotations indicating system on/off times and valve statuses.]
Heat Pump R407C-Suniso 3GS Oil Circulation Tests (46&47)

Heating Mode - No Oil Injection

System Pressures

Pressure (psig)

Hours
Heat Pump R407C-Suniso 3GS Oil Circulation Tests (46&47)
Heating Mode - No Oil Injection

Defrost

Mass Flowrate (lbm/hr)

Vapor Velocity (ft/min)

Time (hrs)

1 valve open
1 valve open
System turned off

2 open

1 valve open

3 open

4 vpen

4 vpen (1000 cfm)

2 open

3 open

4 vpen

4 vpen (1000 cfm)
Heat Pump R407C-Suniso 3GS Oil Circulation Tests (48&49)

Heating Mode - Oil Injection

System Temperatures

SLO 2/29/96
Refrigerant/Lubricant Test Series

R407C - Suniso 1GS
Heat Pump R407C-Suniso 1GS Oil Circulation Test (50)

System Temperatures

Cooling Mode - No Oil Injection

TS1, TS2, TS3, TS4, TS5, TS6, TS7, TS8

System turned off

Temperature (°F)

Hours

SLO 3/1/96

39
Heat Pump R407C-Suniso 1GS Oil Circulation Test (50)
Cooling Mode - No Oil Injection
System Pressures

Pressure (psig) vs. Hours

PS1, PS2, PS3, PS4, PS5, PS6

System turned off

SLO 3/11/96
Heat Pump R407C-Suniso 1GS Oil Circulation Test (50)

Cooling Mode - No Oil Injection

Mass Flowrate (lbm/hr)

Vapor Velocity (ft/min)

Time (hrs)

1 open

2 open

3 open

4 open

System turned off
Heat Pump R407C-Suniso 1GS Oil Circulation Tests (51&52)

Cooling & Heating Mode - No Oil Injection

System Temperatures

Changed to Heating

Temperature (°F)

Hours

TS1 TS2 TS3 TS4 TS5 TS6 TS7 TS8
Heat Pump R407C-Suniso 1GS Oil Circulation Tests (51&52)

Cooling & Heating Mode - No Oil Injection

System Pressures

Pressure (psig)

Hours

PS1

PS2

PS3

PS4

PS5

PS6

Changed to Heating

SLO 3/12/96
Heat Pump R407C-Suniso 1GS Oil Circulation Tests (51&52)

Cooling & Heating Mode - No Oil Injection

Air Side Temperatures

Temperature (°F) vs Hours

- TIE1
- TIE2
- TII1
- TII2
- TOE1
- TOE2
- TOI1
- TOI2

Changed to Heating

TOE

TOI

TII

SLO 3/12/96
Heat Pump R407C-Suniso 1GS Oil Circulation Tests (51&52)
Cooling & Heating Mode - No Oil Injection

Oil Flows

Oil Concentration (%)

Vapor Velocity (ft/min)

Time (hrs)

1 open
2 open
3 open
4 open

cfm 500

Changed to Heating

1 open
2 open
3 open
4 open
Refrigerant/Lubricant Test Series

R407C - Castrol SW32
Heat Pump R407C - Castrol SW32 Oil Circulation Tests (9&10)

Cooling Mode - Oil Injection

System Temperatures

TS1
TS5
TS4
TS8
TS7
TS6
TS3
TS2

Temperature (°F)

0 20 40 60 80 100 120 140 160 180 200

Hours

0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8

TS1 TS2 TS3 TS4 TS5 TS6 TS7 TS8
Heat Pump R407C - Castrol SW32 Oil Circulation Tests (9&10)

Cooling Mode - Oil Injection

System Pressures

Pressure (psig)

Hours

PS1
PS2
PS3
PS4
PS5
PS6
Heat Pump R407C - Castrol SW32 Oil Circulation Tests (9&10)

Cooling Mode - Oil Inception

Air Side Temperatures

TOE  TOI  TII  TIE

Temperature (°F)

Hours

1.8  1.6  1.4  1.2  1

0.8  0.6  0.4  0.2  0

120  110  100  90  80  70  60  50  40  30  20  10  0

TIE1  TIE2  TII1  TII2  TOE1  TOE2  TOI1  TOI2
Heat Pump R407C - Castrol SW32 Oil Circulation Tests (11&12)

Heating Mode - No Oil Injection

System Temperatures

Temperature (°F)

TS1
TS2
TS3
TS5
TS8
TS4
TS6
TS7

Hours

0 1 2 3 4 5 6
Heat Pump R407C - Castrol SW32 Oil Circulation Tests (11&12)
Heat Pump R407C - Castrol SW32 Oil Circulation Tests (11&12)

Heating Mode - No Oil Injection

Oil Flows

Oil Concentration (%)

Vapor Velocity (ft/min)

Time (hrs)
Heat Pump R407C-Castrol SW32 Oil Circulation Test (13)

Heating Mode - No Oil Injection

System Temperatures

System turned off

System turned on

TS1 TS2 TS3 TS4 TS5 TS6 TS7 TS8

Temperature (°F)

Hours

SLO 2/8/96

65
Heat Pump R407C-Castrol SW32 Oil Circulation Test (13)
Heating Mode - No Oil Injection

Oil Flows

System turned on

Oil Concentration (%)

Vapor Velocity (ft/min)

Time (hrs)
Heat Pump R407C-Castrol SW32 Oil Circulation Test (13)
Heating Mode - No Oil Injection

System turned on
Heat Pump R407C - Castrol SW32 Oil Circulation Test (14)

Heating Mode - Oil Injection
System Temperatures

THS 2/29/96
Heat Pump R407C - Castrol SW32 Oil Circulation Test (14)

Heating Mode - Oil Injection

Oil Flows

Vapor Velocity (liter/min)

Oil Concentration (%)

Time (hrs)

1 valve open

2 valves open

3 valves open

4 valves open

73
Refrigerant/Lubricant Test Series

R407C - Castrol SW68
Heat Pump R407C - Castrol SW68 Oil Circulation Tests (15&16)
Cooling Mode - No Oil Injection
System Temperatures

Temperature (F)

Hours

TS1
TS2
TS3
TS4
TS5
TS6
TS7
TS8
Heat Pump R407C - Castrol SW68 Oil Circulation Tests (15&16)

Cooling Mode - No Oil Injection

Air Side Temperatures

Temperature (°F)

Hours

TOE

TOI

TII

TIE

TIE1

TIE2

TII1

TII2

TOE1

TOE2

TOI1

TOI2
Heat Pump R407C - Castrol SW68 Oil Circulation Tests (15&16)

Cooling Mode - No Oil Injection

THS 2/29/96
Heat Pump R407C- Castrol SW68 Oil Circulation Test (17)

Cooling Mode - Oil Injection

System Temperatures

SLO 2/8/96

Temperature (°F)

Hours

TS1
TS2
TS3
TS4
TS5
TS6
TS7
TS8
Heat Pump R407C - Castrol SW68 Oil Circulation Test (17)

Cooling Mode - Oil Injection

SLO 2/8/96

Graph showing mass flow rate and vapor velocity over time with notations for valve positions and system turn off.
Heat Pump R407C - Castrol SW68 Oil Circulation Test (18)

Cooling Mode - Oil Injection

Oil Flows

Time (hrs)

1 valve open

2 valves open

3 valves open

4 valves open

Oil Concentration (%)

Vapor Velocity (ft/min)
Heat Pump R407C - Castrol SW68 Oil Circulation Test (18)
Cooling Mode - Oil Injection

Mass Flowrate (lbm/hr)

Vapor Velocity (ft/min)

Time (hrs)

1 valve open
2 valves open
3 valves open
4 valves open

SLO 2/8/96
Heat Pump R407C-Castrol SW68 Oil Circulation Tests (19&20)

Heating Mode - No Oil Injection

System Pressures

System turned off

System turned on

Pressure (psig)

Hours

PS1
PS2
PS3
PS4
PS5
PS6
Heat Pump R407C-Castrol SW68 Oil Circulation Tests (19&20)

Heating Mode - No Oil Injection

Air Side Temperatures

Temperature (°F)

System turned on

System turned off

Hours

TIE

TII

TOE

TOI

TIE1

TIE2

TII1

TII2

TOE1

TOE2

TOI1

TOI2
Heat Pump R407C-Castrol SW68 Oil Circulation Tests (19&20)
Heating Mode - No Oil Injection

SLO 2/9/96

Mass Flowrate (lbm/hr)

Vapor Velocity (ft/min)

System turned on

System turned off

1 valve open

2 valves open

3 valves open

4 valves open

1 valve open

2 valves open

3 valves open

4 valves open

600
500
400
300
200
100
0

0 1 2 3 4 5 6
Time (hrs)
Heat Pump R407C-Castrol SW68 Oil Circulation Test (21)

Heating Mode - Oil Injection

System Pressures

Pressure (psig)

- PS1
- PS2
- PS3
- PS4
- PS5
- PS6

System turned on

Oil Inj

System turned off

Hours
Heat Pump R407C-Castrol SW68 Oil Circulation Test (21)

Heating Mode - Oil Injection
Air Side Temperatures

System turned on

System turned off

TIE1
TIE2
TII1
TII2
TOE1
TOE2
TOI1
TOI2
Heat Pump R407C-Castrol SW68 Oil Circulation Test (21)

Heating Mode - Oil Injection

SLO 2/12/96

System turned off
Heat Pump R407C-Castrol SW68 Oil Circulation Test (22)

Heating Mode - Oil Injection

System Temperatures

System turned on
System turned off

Temperature (°F)

Hours

TS1
TS2
TS3
TS4
TS5
TS6
TS7
TS8
Heat Pump R407C-Castrol SW68 Oil Circulation Test (22)

Heating Mode - Oil Injection
System Pressures

Pressure (psig)

System turned on
System turned off

Hours

PS1
PS2
PS3
PS4
PS5
PS6
Heat Pump R407C - Castrol SW68 Oil Circulation Tests (23&24)

Heating Mode - Oil Injection
System Pressures

PS1  PS2  PS3  PS4  PS5  PS6

Pressure (psig)

350  300  250  200  150  100  50  0

Hours

0  1  2  3  4  5  6
Heat Pump R407C - Castrol SW68 Oil Circulation Tests (23&24)

Heating Mode - Oil Injection
Air Side Temperatures

SLO 2/19/96
Heat Pump R407C - Castrol SW68 Oil Circulation Tests (25&26)

Heating Mode - No Oil Injection

System Temperatures

SLO 2/20/96

Diagram shows temperature changes over time for various sensors (TS1, TS2, TS3, TS4, TS5, TS6, TS7, TS8) with notes on system events such as 'Fan off' and 'System turned off.'
Heat Pump R407C - Castrol SW68 Oil Circulation Tests (25&26)

Heating Mode - No Oil Injection

System Pressures

System turned off

Pressure (psig)

Hours

PS1
PS2
PS3
PS4
PS5
PS6
Refrigerant/Lubricant Test Series

R407C - ICI RL32S
Heat Pump R407C - ICI RL32S Oil Circulation Tests (27&28)

Cooling Mode - No Oil Injection

System Temperatures

- Changed to heating then back to cooling
- System turned on
- System turned off

TS1, TS2, TS3, TS4, TS5, TS6, TS7, TS8

Temperature (°F) vs Hours
Heat Pump R407C - ICI RL32S Oil Circulation Tests (27&28)

Cooling Mode - No Oil Injection
System Pressures

- PS1
- PS2
- PS3
- PS4
- PS5
- PS6

- System turned off
- System turned on
- cfm changing

Pressure (psig)

0  5  10  15  20  25  30  35

Hours

Heating turned on then back to Cooling

SLO 2/20/96
Heat Pump R407C- ICI RL32S Oil Circulation Tests (29&30)
Heating Mode - No Oil Injection
System Temperatures

Temperature (°F)

Hours

System turned off

Defrost

TS1

TS2

TS3

TS4

TS5

TS6

TS7

TS8
Heat Pump R407C - ICI RL32S Oil Circulation Tests (29&30)

Heating Mode - No Oil Injection
Air Side Temperatures

System turned off
Heat Pump R407C - ICI RL32S Oil Circulation Tests (31-33)

Cooling Mode - Oil Injection

System Temperatures

System turned on

System turned off

Changed to Heating then back to Cooling
Heat Pump R407C - ICI RL32S Oil Circulation Test (34)

Heating Mode - No Oil Injection
Air Side Temperatures

SLO 2/21/96

Temperature (°F)

Hours

System turned on

System turned off

Bypass Open

TIE

TII

TOI

TOE

TIE1

TII1

TOE1

TIE2

TII2

TOE2

TOI1

TOI2
Heat Pump R407C - ICI RL32S Oil Circulation Test (34)

Heating Mode - No Oil Injection

Oil Flows

Oil Concentration (%)

Vapor Velocity (ft/min)

Time (hrs)

System turned on

Changed to Heating

1 valve open

2 valves open

3 valves open

4 valves open

Defrost

4 valves open (1000 cfm)

1 valve open

4 valves open

System turned off