

**Solstice<sup>®</sup> yf**

Properties and Materials Compatibility

## Guidelines for Use and Handling of Solstice<sup>®</sup> yf

This brochure provides selected properties information for Solstice<sup>®</sup> yf including thermodynamic data, transport properties, and flammability characteristics. Solstice yf was originally developed as a low global warming potential replacement for R-134a in the automobile air-conditioning application. Because of its desirable environmental properties, along with other factors, it is being investigated in a number of stationary applications as well.

### Flammability

Solstice yf can be described as being “mildly flammable” as measured by standard methodology.

This descriptor is used to characterize the flammability in simplistic terms; however, properties such as minimum ignition energy, heat of combustion, and the burning velocity are assessed in order to arrive at such a descriptor. Measurement of Solstice yf flammability properties indicates that a typical static discharge will not have sufficient energy to ignite Solstice yf. Available data appears below.

|  |              |
|--|--------------|
| Upper Flammability Limit [Vol. % in air] (21°C, ASTM E681-01)  | 12.3         |
| Lower Flammability Limit [Vol. % in air] (21°C, ASTM E681-01)  | 6.2          |
| Minimum Ignition Energy [mJ at 20 °C and 1 atm]<br>(In-house method. Tests conducted in 12 liter flask to minimize wall quenching effects) | 5000-10000   |
| Autoignition Temperature [°C]<br>(EC Physico/Chemical Test A15, Measured by Chilworth Technology, UK)                                      | 405          |
| Heat of Combustion [MJ/kg] per ASHRAE Standard 34<br>(Stoichiometric composition 7.73% in air)   | 11.8         |
| Fundamental burning velocity [cm/s]<br>(per ISO 817, Measured by AIST, Japan)  | 1.5          |
| Minimum Ignition Current<br>(per IEC 79-3, 3rd ed., 1990; measured by UL)  | No ignition* |
| Minimum Ignition Current Ratio<br>(per IEC 79-3, 3rd ed., 1990; measured by UL)  | >>1          |

*\*Unable to obtain ignition for any current level or test gas mixture when using calibration circuit or spark plug box. After no ignition was obtained using the calibration circuit, attempts were made to obtain ignition using a spark plug.*

It is recommended that risk assessment and risk minimization for use of Solstice yf in facilities and applications should be conducted prior to use.

## SELECTED PHYSICAL PROPERTIES

|  |                                 |
|--|---------------------------------|
| Chemical Name                                  | 2,3,3,3-Tetrafluoroprop-1-ene   |
| Molecular Formula                              | CH <sub>2</sub> CF <sub>3</sub> |
| Molecular Weight                               | 114                             |
| % Volatiles by Volume                          | 100                             |
| Water Solubility (in Solstice yf, ppm by mass) | 200                             |
| ASHRAE Safety Group Classification             | A2L                             |

## ENGLISH UNITS

|   |               |
|---|---------------|
| Boiling Point (°F) @ 1atm                                 | -21           |
| Freezing Point (°F)                                       | Not available |
| Critical Temperature (°F)                                 | 202.5         |
| Critical Pressure (psia)                                  | 490.6         |
| Critical Density (lb/ft <sup>3</sup> )                    | 29.7          |
| Vapor Density @ 20°C, 1 atm (lb/ft <sup>3</sup> )         | 0.303         |
| Liquid Density (lb/ft <sup>3</sup> )                      | 68.2          |
| Liquid Heat Capacity (Btu/lb °F)                          | 0.33          |
| Vapor Heat Capacity @ constant pressure, 1atm (Btu/lb °F) | 0.22          |
| Heat of Vaporization at 1 atm (Btu/lb)                    | 77.53         |
| Vapor Pressure at 77°F (psia)                             | 99            |
| Liquid Thermal Conductivity (Btu/hr-ft °F)                | 0.0368        |
| Vapor Thermal Conductivity (Btu/hr-ft °F)                 | 0.008         |
| Liquid Viscosity (lb/ft-hr)                               | 0.38          |
| Vapor Viscosity (lb/ft-hr)                                | 0.03          |

## STANDARD INTERNATIONAL UNITS

|   |               |
|---|---------------|
| Boiling Point [°C] @ 1.01 bar                               | -29.5         |
| Freezing Point[°C] @1.01 bar                                | Not available |
| Critical Temperature [°C]                                   | 94.7          |
| Critical Pressure[bar]                                      | 33.8          |
| Critical Density [kg/m <sup>3</sup> ]                       | 475.6         |
| Vapor Density @ 20°C, 1 atm [kg/m <sup>3</sup> ]            | 4.79          |
| Liquid Density [kg/m <sup>3</sup> ]                         | 1091.9        |
| Liquid Heat Capacity [kJ/kg K]                              | 1.39          |
| Vapor Heat Capacity @ constant pressure, 1.01 bar [kJ/kg K] | 0.91          |
| Heat of Vaporization at 1 atm [kJ/kg]                       | 180.25        |
| Vapor Pressure at 25°C [bar]                                | 6.83          |
| Liquid Thermal Conductivity [mW/m·K]                        | 63.59         |
| Vapor Thermal Conductivity [mW/m·K]                         | 13.97         |
| Liquid Viscosity [°Paμs]                                    | 155.5         |
| Vapor Viscosity [°Paμs]                                     | 12.3          |

*Flame Limits measured at ambient temperature and pressure using ASTM E681-85 with electrically heated match ignition, spark ignition and fused wire ignition; ambient air. All measurements at 77°F (25 °C) unless otherwise noted.*

## Thermodynamic & Transport Data – SI Units (reference state: IIR)

| Temp<br>°C | Pressure<br>kPa | Density<br>kg/m <sup>3</sup> |        | Enthalpy<br>kJ/kg |       | Entropy<br>kJ/kg·K |        | cp<br>kJ/kg·K |       | cv<br>kJ/kg·K |       |
|------------|-----------------|------------------------------|--------|-------------------|-------|--------------------|--------|---------------|-------|---------------|-------|
|            |                 | Liquid                       | Vapor  | Liquid            | Vapor | Liquid             | Vapor  | Liquid        | Vapor | Liquid        | Vapor |
| -40        | 62.4            | 1291.9                       | 3.7945 | 151.1             | 336.6 | 0.8074             | 6031   | 1.16          | 0.78  | 0.78          | 0.69  |
| -38        | 68.7            | 1286.5                       | 4.1519 | 153.4             | 337.9 | 0.8173             | 1.6020 | 1.16          | 0.78  | 0.79          | 0.70  |
| -36        | 75.5            | 1281.0                       | 4.5353 | 155.7             | 339.3 | 0.8272             | 1.6011 | 1.17          | 0.79  | 0.79          | 0.70  |
| -34        | 82.8            | 1275.6                       | 4.946  | 158.1             | 340.6 | 0.8370             | 1.6003 | 1.18          | 0.80  | 0.80          | 0.71  |
| -32        | 90.6            | 1270.1                       | 5.3856 | 160.4             | 342.0 | 0.8468             | 1.5996 | 1.18          | 0.80  | 0.80          | 0.71  |
| -30        | 99.1            | 1264.5                       | 5.8553 | 162.8             | 343.3 | 0.8566             | 1.5990 | 1.19          | 0.81  | 0.81          | 0.72  |
| -28        | 108.1           | 1259.0                       | 6.3566 | 165.2             | 344.7 | 0.8663             | 1.5984 | 1.19          | 0.82  | 0.81          | 0.72  |
| -26        | 117.8           | 1253.4                       | 6.8911 | 167.6             | 346.0 | 0.8760             | 1.5980 | 1.20          | 0.83  | 0.81          | 0.73  |
| -24        | 128.1           | 1247.7                       | 7.4602 | 170.0             | 347.4 | 0.8857             | 1.5976 | 1.21          | 0.83  | 0.82          | 0.74  |
| -22        | 139.2           | 1242.0                       | 8.0658 | 172.4             | 348.7 | 0.8954             | 1.5973 | 1.21          | 0.84  | 0.82          | 0.74  |
| -20        | 150.9           | 1236.3                       | 8.7093 | 174.9             | 350.1 | 0.9050             | 1.5970 | 1.22          | 0.85  | 0.83          | 0.75  |
| -18        | 163.4           | 1230.5                       | 9.3925 | 177.3             | 351.4 | 0.9146             | 1.5968 | 1.23          | 0.85  | 0.83          | 0.75  |
| -16        | 176.8           | 1224.7                       | 10.117 | 179.8             | 352.7 | 0.9242             | 1.5967 | 1.23          | 0.86  | 0.84          | 0.76  |
| -14        | 190.9           | 1218.8                       | 10.885 | 182.3             | 354.1 | 0.9338             | 1.5967 | 1.24          | 0.87  | 0.84          | 0.76  |
| -12        | 205.9           | 1212.9                       | 11.699 | 184.8             | 355.4 | 0.9433             | 1.5967 | 1.25          | 0.88  | 0.84          | 0.77  |
| -10        | 221.8           | 1207.0                       | 12.559 | 187.3             | 356.7 | 0.9528             | 1.5968 | 1.25          | 0.88  | 0.85          | 0.77  |
| -8         | 238.6           | 1200.9                       | 13.469 | 189.8             | 358.0 | 0.9623             | 1.5969 | 1.26          | 0.89  | 0.85          | 0.78  |
| -6         | 256.4           | 1194.9                       | 14.431 | 192.3             | 359.4 | 0.9717             | 1.5970 | 1.27          | 0.90  | 0.86          | 0.79  |
| -4         | 275.1           | 1188.7                       | 15.446 | 194.9             | 360.7 | 0.9812             | 1.5973 | 1.27          | 0.91  | 0.86          | 0.79  |
| -2         | 295.0           | 1182.5                       | 16.517 | 197.4             | 362.0 | 0.9906             | 1.5975 | 1.28          | 0.92  | 0.86          | 0.80  |
| 0          | 315.8           | 1176.3                       | 17.647 | 200.0             | 363.3 | 1.0000             | 1.5978 | 1.29          | 0.93  | 0.87          | 0.80  |
| 2          | 337.8           | 1170.0                       | 18.837 | 202.6             | 364.6 | 1.0094             | 1.5981 | 1.30          | 0.93  | 0.87          | 0.81  |
| 4          | 360.9           | 1163.6                       | 20.092 | 205.2             | 365.9 | 1.0187             | 1.5985 | 1.30          | 0.94  | 0.87          | 0.81  |
| 6          | 385.2           | 1157.2                       | 21.413 | 207.8             | 367.2 | 1.0281             | 1.5989 | 1.31          | 0.95  | 0.88          | 0.82  |
| 8          | 410.8           | 1150.6                       | 22.804 | 210.5             | 368.4 | 1.0374             | 1.5993 | 1.32          | 0.96  | 0.88          | 0.83  |
| 10         | 437.5           | 1144.0                       | 24.267 | 213.1             | 369.7 | 1.0467             | 1.5998 | 1.33          | 0.97  | 0.89          | 0.83  |
| 12         | 465.6           | 1137.4                       | 25.807 | 215.8             | 371.0 | 1.0560             | 1.6003 | 1.34          | 0.98  | 0.89          | 0.84  |
| 14         | 495.0           | 1130.6                       | 27.425 | 218.5             | 372.2 | 1.0653             | 1.6008 | 1.34          | 0.99  | 0.89          | 0.84  |
| 16         | 525.8           | 1123.8                       | 29.127 | 221.2             | 373.5 | 1.0746             | 1.6013 | 1.35          | 1.00  | 0.90          | 0.85  |
| 18         | 558.0           | 1116.9                       | 30.916 | 223.9             | 374.7 | 1.0838             | 1.6018 | 1.36          | 1.01  | 0.90          | 0.85  |
| 20         | 591.7           | 1109.9                       | 32.796 | 226.6             | 375.9 | 1.0931             | 1.6024 | 1.37          | 1.02  | 0.90          | 0.86  |
| 22         | 626.9           | 1102.8                       | 34.772 | 229.3             | 377.1 | 1.1023             | 1.6029 | 1.38          | 1.04  | 0.91          | 0.87  |
| 24         | 663.6           | 1095.5                       | 36.848 | 232.1             | 378.3 | 1.1115             | 1.6034 | 1.39          | 1.05  | 0.91          | 0.87  |
| 26         | 701.9           | 1088.2                       | 39.029 | 234.9             | 379.5 | 1.1208             | 1.6040 | 1.40          | 1.06  | 0.91          | 0.88  |

| Temp<br>°C | Pressure<br>kPa | Density<br>kg/m <sup>3</sup> |        | Enthalpy<br>kJ/kg |       | Entropy<br>kJ/kg·K |        | cp<br>kJ/kg·K |       | cv<br>kJ/kg·K |       |
|------------|-----------------|------------------------------|--------|-------------------|-------|--------------------|--------|---------------|-------|---------------|-------|
|            |                 | Liquid                       | Vapor  | Liquid            | Vapor | Liquid             | Vapor  | Liquid        | Vapor | Liquid        | Vapor |
| 28         | 741.9           | 1080.8                       | 41.321 | 237.7             | 380.6 | 1.1300             | 1.6045 | 1.41          | 1.07  | 0.92          | 0.88  |
| 30         | 783.5           | 1073.3                       | 43.729 | 240.5             | 381.8 | 1.1392             | 1.6051 | 1.42          | 1.09  | 0.92          | 0.89  |
| 32         | 826.9           | 1065.7                       | 46.26  | 243.4             | 382.9 | 1.1484             | 1.6056 | 1.43          | 1.10  | 0.92          | 0.90  |
| 34         | 872.0           | 1057.9                       | 48.92  | 246.2             | 384.0 | 1.1576             | 1.6061 | 1.44          | 1.12  | 0.93          | 0.90  |
| 36         | 918.9           | 1050.0                       | 51.717 | 249.1             | 385.1 | 1.1668             | 1.6066 | 1.45          | 1.13  | 0.93          | 0.91  |
| 38         | 967.7           | 1042.0                       | 54.658 | 252.0             | 386.1 | 1.1759             | 1.6071 | 1.46          | 1.15  | 0.93          | 0.92  |
| 40         | 1018.4          | 1033.8                       | 57.753 | 254.9             | 387.2 | 1.1851             | 1.6075 | 1.47          | 1.17  | 0.94          | 0.92  |
| 42         | 1071.1          | 1025.5                       | 61.01  | 257.8             | 388.2 | 1.1943             | 1.6079 | 1.49          | 1.19  | 0.94          | 0.93  |
| 44         | 1125.7          | 1017.0                       | 64.44  | 260.8             | 389.2 | 1.2035             | 1.6083 | 1.50          | 1.21  | 0.94          | 0.94  |
| 46         | 1182.5          | 1008.3                       | 68.053 | 263.8             | 390.1 | 1.2128             | 1.6087 | 1.51          | 1.23  | 0.95          | 0.94  |
| 48         | 1241.3          | 999.4                        | 71.863 | 266.8             | 391.1 | 1.2220             | 1.6089 | 1.53          | 1.25  | 0.95          | 0.95  |
| 50         | 1302.3          | 990.4                        | 75.884 | 269.9             | 392.0 | 1.2312             | 1.6092 | 1.55          | 1.28  | 0.96          | 0.96  |
| 52         | 1365.6          | 981.1                        | 80.13  | 272.9             | 392.9 | 1.2405             | 1.6094 | 1.57          | 1.30  | 0.96          | 0.97  |
| 54         | 1431.1          | 971.6                        | 84.619 | 276.0             | 393.7 | 1.2498             | 1.6095 | 1.59          | 1.33  | 0.96          | 0.97  |
| 56         | 1498.9          | 961.8                        | 89.371 | 279.2             | 394.5 | 1.2592             | 1.6095 | 1.61          | 1.37  | 0.97          | 0.98  |
| 58         | 1569.2          | 951.7                        | 94.407 | 282.3             | 395.2 | 1.2685             | 1.6095 | 1.63          | 1.40  | 0.97          | 0.99  |
| 60         | 1641.9          | 941.3                        | 99.754 | 285.5             | 395.9 | 1.2779             | 1.6093 | 1.66          | 1.44  | 0.97          | 1.00  |
| 62         | 1717.1          | 930.6                        | 105.44 | 288.8             | 396.6 | 1.2874             | 1.6091 | 1.68          | 1.49  | 0.98          | 1.01  |
| 64         | 1794.9          | 919.5                        | 111.5  | 292.1             | 397.2 | 1.2969             | 1.6087 | 1.72          | 1.53  | 0.98          | 1.01  |
| 66         | 1875.4          | 907.9                        | 117.96 | 295.4             | 397.7 | 1.3065             | 1.6082 | 1.75          | 1.59  | 0.98          | 1.02  |
| 68         | 1958.6          | 895.8                        | 124.89 | 298.8             | 398.2 | 1.3162             | 1.6076 | 1.79          | 1.65  | 0.99          | 1.03  |
| 70         | 2044.5          | 883.2                        | 132.33 | 302.2             | 398.6 | 1.3260             | 1.6068 | 1.84          | 1.72  | 0.99          | 1.04  |

## Thermodynamic & Transport Data – SI Units (reference state: IIR)

| Temp<br>°C | Pressure<br>kPa | Speed of Sound<br>m/s |       | Thermal Conductivity<br>mW/m•K |       | Viscosity<br>μPa•s |       | Surface<br>Tension<br>mN/m |
|------------|-----------------|-----------------------|-------|--------------------------------|-------|--------------------|-------|----------------------------|
|            |                 | Liquid                | Vapor | Liquid                         | Vapor | Liquid             | Vapor | Liquid                     |
| -40        | 62.4            | 735.9                 | 133.7 | 85.5                           | 8.5   | 358.5              | 9.5   | 15.2                       |
| -38        | 68.7            | 726.7                 | 134.0 | 84.8                           | 8.7   | 347.8              | 9.6   | 14.8                       |
| -36        | 75.5            | 717.5                 | 134.2 | 84.1                           | 8.8   | 337.6              | 9.7   | 14.5                       |
| -34        | 82.8            | 708.4                 | 134.4 | 83.3                           | 9.0   | 327.9              | 9.8   | 14.2                       |
| -32        | 90.6            | 699.4                 | 134.7 | 82.6                           | 9.1   | 318.5              | 9.9   | 13.9                       |
| -30        | 99.1            | 690.4                 | 134.9 | 81.9                           | 9.3   | 309.6              | 9.9   | 13.6                       |
| -28        | 108.1           | 681.4                 | 135.0 | 81.2                           | 9.4   | 301.0              | 10.0  | 13.3                       |
| -26        | 117.8           | 672.5                 | 135.2 | 80.5                           | 9.6   | 292.8              | 10.1  | 13.0                       |
| -24        | 128.1           | 663.6                 | 135.4 | 79.8                           | 9.7   | 284.9              | 10.2  | 12.7                       |
| -22        | 139.2           | 654.8                 | 135.5 | 79.1                           | 9.9   | 277.3              | 10.3  | 12.5                       |
| -20        | 150.9           | 646.0                 | 135.6 | 78.4                           | 10.0  | 269.9              | 10.3  | 12.2                       |
| -18        | 163.4           | 637.2                 | 135.7 | 77.7                           | 10.2  | 262.9              | 10.4  | 11.9                       |
| -16        | 176.8           | 628.5                 | 135.7 | 77.0                           | 10.3  | 256.1              | 10.5  | 11.6                       |
| -14        | 190.9           | 619.7                 | 135.8 | 76.3                           | 10.5  | 249.6              | 10.6  | 11.3                       |
| -12        | 205.9           | 611.0                 | 135.8 | 75.6                           | 10.7  | 243.2              | 10.7  | 11.0                       |
| -10        | 221.8           | 602.4                 | 135.8 | 74.9                           | 10.8  | 237.1              | 10.7  | 10.7                       |
| -8         | 238.6           | 593.7                 | 135.8 | 74.3                           | 11.0  | 231.2              | 10.8  | 10.5                       |
| -6         | 256.4           | 585.1                 | 135.7 | 73.6                           | 11.2  | 225.5              | 10.9  | 10.2                       |
| -4         | 275.1           | 576.4                 | 135.6 | 72.9                           | 11.3  | 220.0              | 11.0  | 9.9                        |
| -2         | 295.0           | 567.8                 | 135.5 | 72.3                           | 11.5  | 214.6              | 11.1  | 9.6                        |
| 0          | 315.8           | 559.2                 | 135.4 | 71.6                           | 11.7  | 209.4              | 11.2  | 9.4                        |
| 2          | 337.8           | 550.6                 | 135.2 | 70.9                           | 11.8  | 204.4              | 11.2  | 9.1                        |
| 4          | 360.9           | 542.0                 | 135.1 | 70.3                           | 12.0  | 199.5              | 11.3  | 8.8                        |
| 6          | 385.2           | 533.4                 | 134.8 | 69.6                           | 12.2  | 194.7              | 11.4  | 8.6                        |
| 8          | 410.8           | 524.8                 | 134.6 | 69.0                           | 12.4  | 190.1              | 11.5  | 8.3                        |
| 10         | 437.5           | 516.2                 | 134.3 | 68.3                           | 12.5  | 185.6              | 11.6  | 8.0                        |
| 12         | 465.6           | 507.5                 | 134.1 | 67.7                           | 12.7  | 181.3              | 11.7  | 7.8                        |
| 14         | 495.0           | 498.9                 | 133.7 | 67.1                           | 12.9  | 177.0              | 11.8  | 7.5                        |
| 16         | 525.8           | 490.3                 | 133.4 | 66.4                           | 13.1  | 172.9              | 11.9  | 7.3                        |
| 18         | 558.0           | 481.6                 | 133.0 | 65.8                           | 13.3  | 168.8              | 11.9  | 7.0                        |
| 20         | 591.7           | 472.9                 | 132.6 | 65.2                           | 13.5  | 164.9              | 12.0  | 6.8                        |

| Temp<br>°C | Pressure<br>kPa | Speed of Sound<br>m/s |       | Thermal Conductivity<br>mW/m•K |       | Viscosity<br>μPa•s |       | Surface<br>Tension<br>mN/m |
|------------|-----------------|-----------------------|-------|--------------------------------|-------|--------------------|-------|----------------------------|
|            |                 | Liquid                | Vapor | Liquid                         | Vapor | Liquid             | Vapor | Liquid                     |
| 22         | 626.9           | 464.2                 | 132.1 | 64.5                           | 13.7  | 161.1              | 12.1  | 6.5                        |
| 24         | 663.6           | 455.5                 | 131.7 | 63.9                           | 13.9  | 157.3              | 12.2  | 6.3                        |
| 26         | 701.9           | 446.8                 | 131.1 | 63.3                           | 14.1  | 153.6              | 12.3  | 6.0                        |
| 28         | 741.9           | 438.1                 | 130.6 | 62.7                           | 14.3  | 150.0              | 12.4  | 5.8                        |
| 30         | 783.5           | 429.3                 | 130.0 | 62.0                           | 14.5  | 146.5              | 12.6  | 5.6                        |
| 32         | 826.9           | 420.5                 | 129.4 | 61.4                           | 14.7  | 143.1              | 12.7  | 5.3                        |
| 34         | 872.0           | 411.7                 | 128.8 | 60.8                           | 14.9  | 139.7              | 12.8  | 5.1                        |
| 36         | 918.9           | 402.9                 | 128.1 | 60.2                           | 15.1  | 136.4              | 12.9  | 4.9                        |
| 38         | 967.7           | 394.1                 | 127.3 | 59.6                           | 15.4  | 133.2              | 13.0  | 4.6                        |
| 40         | 1018.4          | 385.2                 | 126.6 | 59.0                           | 15.6  | 130.0              | 13.2  | 4.4                        |
| 42         | 1071.1          | 376.4                 | 125.7 | 58.4                           | 15.8  | 126.9              | 13.3  | 4.2                        |
| 44         | 1125.7          | 367.4                 | 124.9 | 57.8                           | 16.1  | 123.8              | 13.4  | 4.0                        |
| 46         | 1182.5          | 358.5                 | 124.0 | 57.2                           | 16.3  | 120.8              | 13.6  | 3.8                        |
| 48         | 1241.3          | 349.4                 | 123.1 | 56.6                           | 16.6  | 117.8              | 13.7  | 3.6                        |
| 50         | 1302.3          | 340.3                 | 122.1 | 56.1                           | 16.9  | 114.9              | 13.9  | 3.4                        |
| 52         | 1365.6          | 331.1                 | 121.0 | 55.5                           | 17.2  | 112.0              | 14.0  | 3.2                        |
| 54         | 1431.1          | 321.8                 | 120.0 | 54.9                           | 17.5  | 109.1              | 14.2  | 3.0                        |
| 56         | 1498.9          | 312.3                 | 118.8 | 54.4                           | 17.8  | 106.3              | 14.4  | 2.8                        |
| 58         | 1569.2          | 302.6                 | 117.6 | 53.8                           | 18.1  | 103.5              | 14.6  | 2.6                        |
| 60         | 1641.9          | 292.7                 | 116.4 | 53.3                           | 18.5  | 100.8              | 14.8  | 2.4                        |
| 62         | 1717.1          | 282.6                 | 115.1 | 52.8                           | 18.9  | 98.0               | 15.0  | 2.2                        |
| 64         | 1794.9          | 272.3                 | 113.7 | 52.3                           | 19.3  | 95.3               | 15.3  | 2.0                        |
| 66         | 1875.4          | 261.8                 | 112.3 | 51.8                           | 19.7  | 92.5               | 15.5  | 1.8                        |
| 68         | 1958.6          | 251.0                 | 110.8 | 51.3                           | 20.2  | 89.8               | 15.8  | 1.7                        |
| 70         | 2044.5          | 240.0                 | 109.3 | 50.9                           | 20.8  | 87.1               | 16.1  | 1.5                        |

## Thermodynamic and Transport Data – English Units (reference state: ASHRAE)

| Temp<br>°F | Pressure<br>psia | Density<br>lb <sub>m</sub> /ft <sup>3</sup> |        | Enthalpy<br>Btu/lb <sub>m</sub> |        | Entropy<br>Btu/lb <sub>m</sub> •F |        | cp<br>Btu/lb <sub>m</sub> •F |       | cv<br>Btu/lb <sub>m</sub> •F |       |
|------------|------------------|---|--------|---------------------------------|--------|-----------------------------------|--------|------------------------------|-------|------------------------------|-------|
|            |                  | Liquid                                      | Vapor  | Liquid                          | Vapor  | Liquid                            | Vapor  | Liquid                       | Vapor | Liquid                       | Vapor |
| -40        | 9.0              | 80.65                                       | 0.2369 | 0.00                            | 79.81  | 0.0000                            | 0.1902 | 0.28                         | 0.19  | 0.19                         | 0.17  |
| -35        | 10.3             | 80.18                                       | 0.2683 | 1.39                            | 80.61  | 0.0033                            | 0.1898 | 0.28                         | 0.19  | 0.19                         | 0.17  |
| -30        | 11.8             | 79.71                                       | 0.3029 | 2.79                            | 81.42  | 0.0066                            | 0.1896 | 0.28                         | 0.19  | 0.19                         | 0.17  |
| -25        | 13.3             | 79.23                                       | 0.3410 | 4.20                            | 82.23  | 0.0098                            | 0.1893 | 0.28                         | 0.19  | 0.19                         | 0.17  |
| -20        | 15.1             | 78.75                                       | 0.3827 | 5.62                            | 83.03  | 0.0131                            | 0.1891 | 0.28                         | 0.19  | 0.19                         | 0.17  |
| -15        | 17.0             | 78.26                                       | 0.4283 | 7.05                            | 83.84  | 0.0163                            | 0.1890 | 0.29                         | 0.20  | 0.19                         | 0.17  |
| -10        | 19.1             | 77.77                                       | 0.4781 | 8.50                            | 84.64  | 0.0195                            | 0.1888 | 0.29                         | 0.20  | 0.20                         | 0.18  |
| -5         | 21.4             | 77.28                                       | 0.5323 | 9.95                            | 85.44  | 0.0227                            | 0.1887 | 0.29                         | 0.20  | 0.20                         | 0.18  |
| 0          | 23.9             | 76.78                                       | 0.5913 | 11.41                           | 86.24  | 0.0259                            | 0.1887 | 0.29                         | 0.20  | 0.20                         | 0.18  |
| 5          | 26.6             | 76.27                                       | 0.6552 | 12.89                           | 87.04  | 0.0291                            | 0.1887 | 0.30                         | 0.21  | 0.20                         | 0.18  |
| 10         | 29.6             | 75.76                                       | 0.7245 | 14.37                           | 87.84  | 0.0322                            | 0.1887 | 0.30                         | 0.21  | 0.20                         | 0.18  |
| 15         | 32.8             | 75.24                                       | 0.7995 | 15.87                           | 88.63  | 0.0354                            | 0.1887 | 0.30                         | 0.21  | 0.20                         | 0.19  |
| 20         | 36.3             | 74.72                                       | 0.8805 | 17.38                           | 89.42  | 0.0385                            | 0.1887 | 0.30                         | 0.21  | 0.20                         | 0.19  |
| 25         | 40.1             | 74.19                                       | 0.9679 | 18.90                           | 90.21  | 0.0417                            | 0.1888 | 0.30                         | 0.22  | 0.21                         | 0.19  |
| 30         | 44.1             | 73.65                                       | 1.0620 | 20.43                           | 90.99  | 0.0448                            | 0.1889 | 0.31                         | 0.22  | 0.21                         | 0.19  |
| 35         | 48.5             | 73.11                                       | 1.1633 | 21.98                           | 91.77  | 0.0479                            | 0.1890 | 0.31                         | 0.22  | 0.21                         | 0.19  |
| 40         | 53.1             | 72.55                                       | 1.2723 | 23.54                           | 92.54  | 0.0510                            | 0.1891 | 0.31                         | 0.23  | 0.21                         | 0.19  |
| 45         | 58.1             | 71.99                                       | 1.3893 | 25.11                           | 93.30  | 0.0541                            | 0.1892 | 0.31                         | 0.23  | 0.21                         | 0.20  |
| 50         | 63.5             | 71.42                                       | 1.5150 | 26.69                           | 94.06  | 0.0572                            | 0.1894 | 0.32                         | 0.23  | 0.21                         | 0.20  |
| 55         | 69.2             | 70.84                                       | 1.6498 | 28.28                           | 94.81  | 0.0603                            | 0.1896 | 0.32                         | 0.24  | 0.21                         | 0.20  |
| 60         | 75.3             | 70.25                                       | 1.7943 | 29.89                           | 95.55  | 0.0634                            | 0.1897 | 0.32                         | 0.24  | 0.21                         | 0.20  |
| 65         | 81.7             | 69.65                                       | 1.9492 | 31.51                           | 96.29  | 0.0664                            | 0.1899 | 0.33                         | 0.24  | 0.22                         | 0.20  |
| 70         | 88.6             | 69.04                                       | 2.1152 | 33.15                           | 97.01  | 0.0695                            | 0.1901 | 0.33                         | 0.25  | 0.22                         | 0.21  |
| 75         | 95.9             | 68.42                                       | 2.2930 | 34.80                           | 97.72  | 0.0726                            | 0.1903 | 0.33                         | 0.25  | 0.22                         | 0.21  |
| 80         | 103.7            | 67.78                                       | 2.4834 | 36.46                           | 98.42  | 0.0756                            | 0.1904 | 0.33                         | 0.25  | 0.22                         | 0.21  |
| 85         | 111.9            | 67.14                                       | 2.6874 | 38.14                           | 99.11  | 0.0787                            | 0.1906 | 0.34                         | 0.26  | 0.22                         | 0.21  |
| 90         | 120.6            | 66.47                                       | 2.9060 | 39.84                           | 99.78  | 0.0817                            | 0.1908 | 0.34                         | 0.26  | 0.22                         | 0.21  |
| 95         | 129.8            | 65.80                                       | 3.1402 | 41.55                           | 100.44 | 0.0848                            | 0.1910 | 0.34                         | 0.27  | 0.22                         | 0.22  |
| 100        | 139.6            | 65.10                                       | 3.3914 | 43.28                           | 101.07 | 0.0878                            | 0.1911 | 0.35                         | 0.27  | 0.22                         | 0.22  |
| 105        | 149.8            | 64.39                                       | 3.6608 | 45.02                           | 101.70 | 0.0909                            | 0.1913 | 0.35                         | 0.28  | 0.22                         | 0.22  |
| 110        | 160.6            | 63.67                                       | 3.9502 | 46.78                           | 102.30 | 0.0940                            | 0.1914 | 0.36                         | 0.29  | 0.23                         | 0.22  |
| 115        | 172.0            | 62.92                                       | 4.2613 | 48.57                           | 102.87 | 0.0970                            | 0.1915 | 0.36                         | 0.29  | 0.23                         | 0.23  |
| 120        | 183.9            | 62.14                                       | 4.5962 | 50.37                           | 103.43 | 0.1001                            | 0.1916 | 0.37                         | 0.30  | 0.23                         | 0.23  |
| 125        | 196.5            | 61.35                                       | 4.9572 | 52.20                           | 103.96 | 0.1032                            | 0.1917 | 0.37                         | 0.31  | 0.23                         | 0.23  |
| 130        | 209.7            | 60.52                                       | 5.3471 | 54.05                           | 104.45 | 0.1062                            | 0.1917 | 0.38                         | 0.32  | 0.23                         | 0.23  |
| 135        | 223.6            | 59.66                                       | 5.7692 | 55.94                           | 104.92 | 0.1093                            | 0.1917 | 0.39                         | 0.33  | 0.23                         | 0.24  |
| 140        | 238.1            | 58.77                                       | 6.2274 | 57.85                           | 105.34 | 0.1125                            | 0.1917 | 0.40                         | 0.34  | 0.23                         | 0.24  |
| 145        | 253.4            | 57.83                                       | 6.7265 | 59.79                           | 105.73 | 0.1156                            | 0.1916 | 0.41                         | 0.36  | 0.23                         | 0.24  |
| 150        | 269.4            | 56.84                                       | 7.2722 | 61.77                           | 106.06 | 0.1188                            | 0.1914 | 0.42                         | 0.38  | 0.23                         | 0.24  |



## Thermodynamic and Transport Data – English Units (reference state: ASHRAE)

| Temp<br>°C | Pressure<br>psia | Speed of Sound<br>ft/s |       | Thermal Conductivity<br>Btu/hr;ft·°F |        | Viscosity<br>lb <sub>m</sub> /ft·hr |        | Surface<br>Tension<br>dyne/cm |
|------------|------------------|------------------------|-------|--------------------------------------|--------|-------------------------------------|--------|-------------------------------|
|            |                  | Liquid                 | Vapor | Liquid                               | Vapor  | Liquid                              | Vapor  | Liquid                        |
| -40        | 9.0              | 2414.3                 | 438.6 | 0.0494                               | 0.0049 | 0.87                                | 0.0231 | 15.2                          |
| -35        | 10.3             | 2372.4                 | 439.8 | 0.0489                               | 0.0050 | 0.83                                | 0.0234 | 14.7                          |
| -30        | 11.8             | 2330.8                 | 440.9 | 0.0483                               | 0.0052 | 0.80                                | 0.0236 | 14.3                          |
| -25        | 13.3             | 2289.6                 | 441.9 | 0.0477                               | 0.0053 | 0.77                                | 0.0239 | 13.9                          |
| -20        | 15.1             | 2248.7                 | 442.8 | 0.0471                               | 0.0054 | 0.74                                | 0.0242 | 13.5                          |
| -15        | 17.0             | 2208.0                 | 443.6 | 0.0465                               | 0.0055 | 0.71                                | 0.0244 | 13.1                          |
| -10        | 19.1             | 2167.6                 | 444.2 | 0.0460                               | 0.0056 | 0.68                                | 0.0247 | 12.7                          |
| -5         | 21.4             | 2127.4                 | 444.7 | 0.0454                               | 0.0058 | 0.66                                | 0.0250 | 12.2                          |
| 0          | 23.9             | 2087.4                 | 445.1 | 0.0449                               | 0.0059 | 0.63                                | 0.0252 | 11.8                          |
| 5          | 26.6             | 2047.5                 | 445.4 | 0.0443                               | 0.0060 | 0.61                                | 0.0255 | 11.4                          |
| 10         | 29.6             | 2007.9                 | 445.5 | 0.0438                               | 0.0062 | 0.59                                | 0.0258 | 11.1                          |
| 15         | 32.8             | 1968.4                 | 445.4 | 0.0432                               | 0.0063 | 0.57                                | 0.0260 | 10.7                          |
| 20         | 36.3             | 1928.9                 | 445.3 | 0.0427                               | 0.0064 | 0.55                                | 0.0263 | 10.3                          |
| 25         | 40.1             | 1889.6                 | 444.9 | 0.0421                               | 0.0066 | 0.53                                | 0.0266 | 9.9                           |
| 30         | 44.1             | 1850.3                 | 444.4 | 0.0416                               | 0.0067 | 0.51                                | 0.0269 | 9.5                           |
| 35         | 48.5             | 1811.1                 | 443.8 | 0.0411                               | 0.0068 | 0.50                                | 0.0271 | 9.1                           |
| 40         | 53.1             | 1771.9                 | 442.9 | 0.0406                               | 0.0070 | 0.48                                | 0.0274 | 8.8                           |
| 45         | 58.1             | 1732.7                 | 441.9 | 0.0400                               | 0.0071 | 0.46                                | 0.0277 | 8.4                           |
| 50         | 63.5             | 1693.4                 | 440.8 | 0.0395                               | 0.0073 | 0.45                                | 0.0280 | 8.0                           |
| 55         | 69.2             | 1654.1                 | 439.4 | 0.0390                               | 0.0074 | 0.43                                | 0.0283 | 7.7                           |
| 60         | 75.3             | 1614.8                 | 437.9 | 0.0385                               | 0.0075 | 0.42                                | 0.0286 | 7.3                           |
| 65         | 81.7             | 1575.3                 | 436.1 | 0.0380                               | 0.0077 | 0.41                                | 0.0289 | 7.0                           |
| 70         | 88.6             | 1535.8                 | 434.2 | 0.0375                               | 0.0079 | 0.39                                | 0.0293 | 6.6                           |
| 75         | 95.9             | 1496.1                 | 432.0 | 0.0370                               | 0.0080 | 0.38                                | 0.0296 | 6.3                           |
| 80         | 103.7            | 1456.3                 | 429.7 | 0.0365                               | 0.0082 | 0.37                                | 0.0299 | 6.0                           |
| 85         | 111.9            | 1416.4                 | 427.1 | 0.0360                               | 0.0083 | 0.36                                | 0.0303 | 5.6                           |
| 90         | 120.6            | 1376.4                 | 424.3 | 0.0355                               | 0.0085 | 0.35                                | 0.0307 | 5.3                           |
| 95         | 129.8            | 1336.4                 | 421.3 | 0.0350                               | 0.0087 | 0.33                                | 0.0311 | 5.0                           |
| 100        | 139.6            | 1296.2                 | 418.0 | 0.0345                               | 0.0089 | 0.32                                | 0.0315 | 4.7                           |
| 105        | 149.8            | 1255.8                 | 414.5 | 0.0340                               | 0.0090 | 0.31                                | 0.0319 | 4.4                           |
| 110        | 160.6            | 1215.3                 | 410.7 | 0.0335                               | 0.0092 | 0.30                                | 0.0324 | 4.1                           |
| 115        | 172.0            | 1174.4                 | 406.6 | 0.0331                               | 0.0094 | 0.29                                | 0.0328 | 3.8                           |
| 120        | 183.9            | 1133.2                 | 402.3 | 0.0326                               | 0.0097 | 0.28                                | 0.0334 | 3.5                           |
| 125        | 196.5            | 1091.4                 | 397.7 | 0.0321                               | 0.0099 | 0.27                                | 0.0339 | 3.2                           |
| 130        | 209.7            | 1048.7                 | 392.7 | 0.0317                               | 0.0101 | 0.26                                | 0.0345 | 2.9                           |
| 135        | 223.6            | 1005.1                 | 387.5 | 0.0312                               | 0.0104 | 0.25                                | 0.0351 | 2.6                           |
| 140        | 238.1            | 960.4                  | 381.9 | 0.0308                               | 0.0107 | 0.24                                | 0.0358 | 2.4                           |
| 145        | 253.4            | 914.2                  | 375.9 | 0.0304                               | 0.0110 | 0.23                                | 0.0366 | 2.1                           |
| 150        | 269.4            | 866.6                  | 369.5 | 0.0300                               | 0.0113 | 0.23                                | 0.0375 | 1.9                           |

## Materials Compatibility

A number of plastics and elastomers were evaluated for compatibility with Solstice yf by SAE's Cooperative Research Program. The information below can serve as a guide to identification of compatible classes of plastics and elastomers. Performance of plastics and elastomers can vary considerably with formulation and conditions of use. Solstice yf is an olefin and, like most olefins, may polymerize if certain conditions are present. Any material that will come in contact with Solstice yf should be thoroughly tested to confirm its compatibility before approved for production. Materials that contain polymerization initiators (including peroxides) and that may come in contact with Solstice yf should be avoided until comprehensive testing is conducted. Materials should be evaluated at the conditions associated with the intended application before adopting use of a particular material, especially in the case of production components.

| <b>PLASTICS</b>            | Rating | 24-hr Post Weight Change, % | Physical Change |
|----------------------------|--------|-----------------------------|-----------------|
| Polyester                  | 1      | 4.4                         | 0               |
| Nylon                      | 1      | -1.5                        | 1               |
| Epoxy                      | 1      | 0.3                         | 1               |
| Polyethylene Terephthalate | 1      | 2.0                         | 0               |
| Polyimide                  | 0      | 0.2                         | 0               |

0= best when weight gain < 1 and physical change = 0

1 = border line when weight gain > 1 and < 10 and / or physical change up to 2

2 = incompatible when weight gain > 10 and/or physical change = 2

## Other Elastomer Information

SAE Cooperative Research Program (CRP) has studied hose permeability and O-ring compatibility using samples from a number of commercial suppliers. Samples were exposed to HFO-1234yf/modified ND-8 (PA G) lubricant. Most samples were within target parameters after exposure. Formulations of the following elastomer types having acceptable performance should be commercially available:

- EPDM
- HNBR
- Neoprene
- Butyl rubber
- Chlorobutyl rubber
- Polyamide elastomer

| <b>ELASTOMERS</b> | Rating | 24-hr Post Linear Swell, % | 24 -hr Post Weight Change, % | 24 -hr Post Change in Hardness |
|-------------------|--------|----------------------------|------------------------------|--------------------------------|
| Neoprene WRT      | 0      | 0.0                        | -0.3                         | 1.0                            |
| HNBR              | 0      | 1.6                        | 5.5                          | -7.0                           |
| NBR               | 0      | -1.2                       | -0.7                         | 4.4                            |
| EPDM              | 0      | -0.5                       | -0.6                         | 4.4                            |
| Silicone          | 1      | -0.5                       | 2.5                          | -14.5                          |
| Butyl Rubber      | 0      | -1.6                       | -1.9                         | 0.5                            |

0 = less than 10% weight gain and less than 10% linear swell and <10 hardness unit change

1 = >10% weight gain or >10% linear swell or >10 hardness unit change

2 = 10% weight gain and >10% linear swell and >10 hardness unit change

**For more information:**  
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