Given:

Liquid methane is commonly used in various cryogenic applications. The critical temperature of methane is 191 K and must be maintained below this temperature to remain in the liquid phase. Methane enters a pump at 110 K and 1 MPa and leaves at 120 K and 5 MPa.

$T_{cr} := 191\ K \qquad T_{in} := 110\ K \qquad P_{in} := 1\ MPa \qquad T_{out} := 120\ K \qquad P_{out} := 5\ MPa$

Required:

Determine the entropy change during this process by

(a) using the table given and

(b) using the Tds relations.

Properties of Liquid Methane					
Temp T, K	Pressure P, MPa	Density ρ, kg/m³	Enthalpy h, kJ/kg	Entropy s, kJ/kg K	Specific Heat c_p, kJ/kg K
110	0.5	425.3	208.3	4.878	3.476
	1	425.8	209.0	4.875	3.471
	2	426.6	210.5	4.867	3.460
	5	429.1	215.0	4.844	3.432
120	0.5	410.4	243.4	5.185	3.551
	1	411.0	244.1	5.180	3.543
	2	412.0	245.4	5.171	3.528
	5	415.2	249.6	5.145	3.486

Solution:

Referring to the table @ $T_{in} = 110.0\ K$ and $P_{in} = 1.000\ MPa$ shows

$s_{in} := 4.875\ \frac{kJ}{kg\ K} \qquad c_{p,in} := 3.471\ \frac{kJ}{kg\ K}$

Referring to the table @ $T_{out} = 120.0\ K$ and $P_{out} = 5.000\ MPa$ shows

$s_{out} := 5.145\ \frac{kJ}{kg\ K} \qquad c_{p,out} := 3.486\ \frac{kJ}{kg\ K}$

Thus the change in entropy when using the tables is

$$\boxed{\Delta s_{table} := s_{out} - s_{in} = 0.2700\ \frac{kJ}{kg\ K}} \qquad \text{(a)}$$

The average c_p value over the process is found by

$$c_{p,avg} := \frac{c_{p,in} + c_{p,out}}{2} = 3.478\ \frac{kJ}{kg\ K}$$

For an incompressible substance the change in entropy is given by

$$\boxed{\Delta s_{Tds} := c_{p,avg} \cdot \ln\left(\frac{T_{out}}{T_{in}}\right) = 0.3027\ \frac{kJ}{kg\ K}} \qquad \text{(b)}$$

The percent difference is found by

$$\%diff := \frac{\left|\Delta s_{table} - \Delta s_{Tds}\right|}{\Delta s_{table}} = 12.10\ \%$$