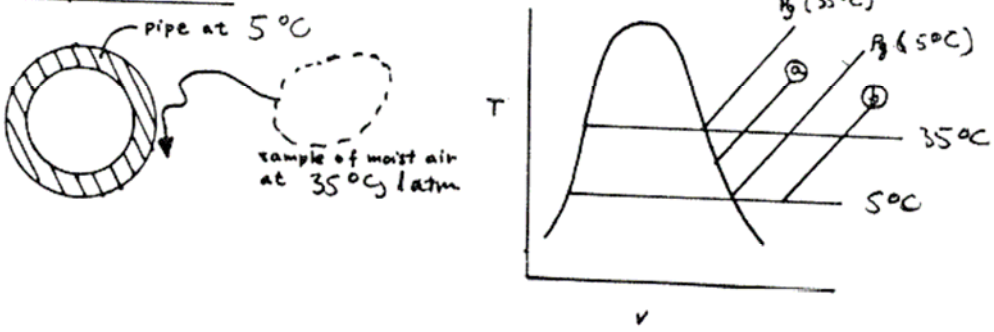
PROBLEM 12.45

KNOWN: A water pipe at 5°C runs between buildings through air at 35°C

FIND: Determine the maximum relative humidity the air can have before condensation occurs on the wall.

SCHEMATIC & GIVEN DATA:



ENGINEERING MODEL: (1) The system consists of a sample of moist air initially at 35°C. (2) As the system comes close to the pipe at 5°C, the system undergoes a cooling process at fixed total pressure from 35°C to 5°C.

ANALYSIS: As the sample of moist air is cooled at fixed total pressure, the partial pressure of the water vapor remains constant as long as no condensation occurs, for $p_v = y_v p$ and y_v remains constant.

Accordingly, if the initial pressure is less than p_g (5°C), such as (b) shown on the T-v diagram, the sample would be cooled to 5°C without condensation. However, if the initial partial pressure is greater than p_g (5°C), such as (a) shown on the T-v diagram, the system would be cooled until a saturated mixture is attained. Subsequent cooling to 5°C would involve condensation. It can be concluded, therefore, that the partial pressure must be less than, or equal to, p_g (5°C). Thus

$$\phi = \frac{p_v}{p_g(35°C)} \leq \frac{p_g(5°C)}{p_g(35°C)} = \frac{0.00872 \text{ bar}}{0.05628 \text{ bar}} = 0.155 \ (15.5\%) \quad \text{---------- } \phi_{max}$$