CLAIMS

What is claimed is:

1. A tubular membrane heat exchanger module comprising:

an inlet header configured to connect to an adjacent upstream tubular membrane heat exchanger module and form an upstream wetted compartment therewith;

an outlet header configured to connect to an adjacent downstream tubular membrane heat exchanger module and form a downstream wetted compartment therewith;

tubular membranes connecting the inlet header and outlet header, the tubular membranes facilitating flow of process fluid from the upstream wetted compartment to the downstream wetted compartment; and

the tubular membranes permitting mass transfer between the process fluid in the tubular membranes and a fluid contacting outer surfaces of the tubular membranes.

2. The tubular membrane heat exchanger module of claim 1 wherein the inlet header includes an inlet opening configured to be covered by the adjacent upstream tubular membrane heat exchanger module; and

wherein the outlet header includes an outlet opening configured to be covered by the adjacent downstream tubular membrane heat exchanger module.

3. The tubular membrane heat exchanger module of claim 1 wherein the inlet header includes an inlet opening and a flange extending about the inlet opening for connecting to the adjacent upstream tubular membrane heat exchanger module.

4. The tubular membrane heat exchanger module of claim 1 wherein the outlet header includes an outlet opening and a flange extending about the outlet opening for connecting to the adjacent downstream tubular membrane heat exchanger module.

5. The tubular membrane heat exchanger module of claim 1 wherein the inlet header and the outlet header include connecting portions configured to form snap-fit connections with the adjacent upstream and downstream tubular membrane heat exchanger modules.

6. The tubular membrane heat exchanger module of claim 1 wherein the inlet header and the outlet header include a projection and a recess configured to engage a corresponding recess and projection of the adjacent upstream and downstream tubular membrane heat exchanger modules.

7. The tubular membrane heat exchanger module of claim 1 wherein the inlet header and the outlet header have identical connecting portions, the inlet header configured to be connected to either of the adjacent upstream and downstream tubular membrane heat exchanger modules and the outlet header configured to be connected to either of the adjacent upstream and downstream tubular membrane heat exchanger modules.

8. The tubular membrane heat exchanger module of claim 1 wherein the inlet header has a single inlet opening to receive process fluid from the adjacent upstream tubular membrane heat exchanger module; and

wherein the outlet header has a single outlet opening to direct process fluid to the downstream tubular membrane heat exchanger module.

9. The tubular membrane heat exchanger module of claim 1 wherein the inlet and outlet headers each comprise:

a plate portion having openings aligned with the tubular membranes; and

a side wall upstanding from the plate portion and having an end portion opposite the plate portion, the end portion of the side wall including a connecting member.

10. The tubular membrane heat exchanger module of claim 9 wherein the connecting member includes at least one of:

a snap-fit member;

a recess;

a flange; and

a wall.

11. The tubular membrane heat exchanger module of claim 1 wherein at least one of the tubular membranes has a lumen to receive the process fluid and a pressure vessel in the lumen to receive a secondary process fluid.

12. The tubular membrane heat exchanger module of claim 1 wherein at least one of the tubular membranes has a lumen to receive the process fluid, a side wall extending about the lumen, and a support in the lumen to resist deformation of the side wall.

13. The tubular membrane heat exchanger module of claim 1 wherein the tubular membranes have side walls with openings having diameters in a range of 1 nanometer to 20 nanometers.

14. The tubular membrane heat exchanger module of claim 1 wherein the inlet and outlet headers include header bodies and potting securing the tubular membranes to the header bodies.

15. The tubular membrane heat exchanger module of claim 1 wherein the inlet and outlet headers include:

header bodies;

fittings connecting the tubular membranes to the header bodies; and

potting securing the tubular membranes, fittings, and header bodies.

16. The tubular membrane heat exchanger module of claim 1 wherein the tubular membranes include at least one of:

polypropylene;

polydimethylsiloxane;

polytetrafluoroethylene;
hydrophobic polysulfone; and
graphene oxide.

17. The tubular membrane heat exchanger module of claim 1 wherein the tubular membranes are gas-permeable and liquid-impermeable.

18. The tubular membrane heat exchanger module of claim 1 wherein the tubular membranes are permeable to water vapor and are impermeable to liquid water.

19. The tubular membrane heat exchanger module of claim 1 further comprising a screen to protect the tubular membranes.

20. The tubular membrane heat exchanger module of claim 1 further comprising a support maintaining spacings between the tubular membranes.