[0032] The heat transfer loop 32 comprises, sequentially along a flowpath 54, a pump 56, a heat absorption heat exchanger 58 and a leg 43 of the inter-loop heat exchanger 44 in heat exchange relation with the leg 42. An optional receiver 59 is between the leg 43 and pump 56.

[0033] One or more second fans 60A, 60B (FIGS. 3 and 5) may drive an internal air flow 522A, 522B along respective flowpaths 510A, 510B across the heat absorption heat exchanger. In normal cooling operation, the pump may pump liquid refrigerant of the heat transfer loop to the heat absorption heat exchanger where the refrigerant receives heat from the air flows 522A, 522B. The heat absorption may cause a phase change to vapor. The refrigerant then passes to the leg 43 where it rejects heat to refrigerant in the leg 42. This will re-condense refrigerant to then pass as liquid back to the pump.

[0034] In various implementations, for powering the container, there may be a power cord (not shown) for connecting to an external power source. Additionally, the container may be associated with a generator 62 (FIG. 3, e.g., having an internal combustion engine). For intermodal containers, the generator may be a part of an accessory "genset" that may separately mount to a vehicle (trailer or rail car) carrying the container. Other transport refrigeration systems such as dedicated trailers may integrate the generator into an equipment body mounted to the front of the trailer box. The refrigeration system may include a main controller 64 (e.g., having a processor, memory and storage for running a program to perform the required functions) powered by a main battery 66. The battery is typically a rechargeable battery that charges when the container is plugged into external power or a running genset.

[0035] FIG 3 generically shows a boundary 67 (formed by walls of the equipment module) between the exterior 68 which is open to the external environment and a climate controlled section 69 of the body interior. For safety, the vapor compression loop is kept completely on the exterior side of the boundary with the heat transfer loop line/conduit making two penetrations of that boundary.

[0036] For ease of manufacture or service, the equipment module (box) may be pre-formed as a module mateable to a remainder of the container body (e.g., insertable into an open front end of the body).

[0037] The module 26 comprises a front panel 70 (FIG. 4). The panel 70 may have a plurality of openings of which some may be closed by various means. Two of the openings 72A, 72B are along the respective air flowpaths 510A, 510B of the two evaporator fans. These flowpaths may be isolated from each other or may merely be adjacent halves of a single flowpath

(or may be a combination, separating and merging). In this example, the opening spans the fan, so that a portion of the opening is upstream of the fan and a portion of the opening is downstream. The openings 72A, 72B are closed by respective access panels 80A, 80B (FIG. 4). The exemplary panel 80A includes a rotary gate valve for venting. It may also have a small blower fan 81A to withdraw air from the flowpath 510A (or may rely on leakage across the adjacent evaporator fan). Other valve/gate structures may be provided. Other valve/gate structures may be provided. The exemplary panel 80B lacks any vent/valve.

[0038] A beneficial combination of working fluid for the two loops is propane for the vapor compression loop and carbon dioxide for the heat transfer loop. Both are low cost and non-toxic and propane is a highly efficient refrigerant. Under ANSI/ASHRAE Standard 34-2007, R-290 (propane) is rated A3 (non-toxic, highly flammable) and R744 is rated as A1 (non-toxic, non-flammable).

[0039] In the two respective loops, the total refrigerant charge may consist essentially of said propane and said carbon dioxide, respectively, (e.g., allowing for industry standard levels of contaminants and additives such as corrosion inhibitors) or at least be 50% or at least 90% by weight said propane and said carbon dioxide.

[0040] Various mitigation measures may be taken regarding the two loops. As noted above, propane-carrying components are isolated from the refrigerated compartment and seals around and in the equipment module prevent propane leakage into the refrigerated compartment. Thus, additional safety measures relating to actions once propane has entered the refrigerated compartment may be avoided (e.g., as distinguished from situations where a propane-containing evaporator is exposed to the refrigerated compartment). Mitigation measures may then be limited to external propane leakage and internal carbon dioxide leakage if at all.

[0041] Exemplary propane leakage mitigation is passive and is discussed below.

[0042] Exemplary carbon dioxide mitigation is active responsive to detecting of a refrigerant leak by a detector 232 (FIG. 5). Carbon dioxide detectors are used to maximize produce freshness by controlling carbon dioxide build up in refrigerated containers generally (e.g., including those using refrigerants other than carbon dioxide). That same detector or an added detector may be used to mitigate leaks of carbon dioxide into the refrigerated compartment. A number of possible locations exist for such a detector including locations within the equipment box (e.g., adjacent the evaporator in a duct along one of the flowpaths 510A or 510B either inside or outside the equipment module communicating with the rest of the refrigerated

CLAIMS

1. A refrigerated transport system (20) comprising:
    a body (22) enclosing a refrigerated compartment (69) and comprising:
        a pair of side walls (22C, 22D);
        a top (22A);
        a bottom (22B); and
        one or more doors (28A, 28B); and
    a refrigeration system (30) comprising:
        a vapor compression loop (31) having a first heat exchanger (38) positioned to reject heat to an external environment in a cooling mode;
        a heat transfer loop (32) having a second heat exchanger (58) positioned to absorb heat from the refrigerated compartment in the cooling mode; and
        an inter-loop heat exchanger (44) having a first leg (42) along the vapor compression loop and a second leg (43) along the heat transfer loop in heat exchange relation with the first leg, wherein:
            the refrigeration system is mounted in an equipment module (26), wherein a wall (67) of the equipment module divides the external environment from the refrigerated compartment;
            the inter-loop heat exchanger is on the external environment side of the wall; and
            the second heat exchanger is on the refrigerated compartment side of the wall.

2. The refrigerated transport system of claim 1, wherein:
    the vapor compression loop sequentially comprises:
        a compressor (36);
        said first heat exchanger;
        an expansion device (40); and
        said first leg; and
    the heat transfer loop sequentially comprises:

a pump (56);

said second heat exchanger; and

said second leg.

3. The refrigerated transport system of claim 2, further comprising:

an electric fan (60A, 60B) positioned to drive a recirculating air flow from the refrigerated compartment across the second heat exchanger.

4. The refrigerated transport system of claim 2, wherein:

the first heat exchanger is a refrigerant-air heat exchanger.

5. The refrigerated transport system claim 1, wherein:

the inter-loop heat exchanger is a brazed plate heat exchanger.

6. The refrigerated transport system of claim 1, further comprising:

a carbon dioxide detector.

7. The refrigerated transport system of claim 6 wherein:

the carbon dioxide detector (232) is coupled to control:

a ventilation fan (81A, 60A).

8. The refrigerated transport system of claim 1, wherein:

a refrigerant charge of the vapor compression loop comprises at least 50% by weight propane.

9. The refrigerated transport system of claim 1, wherein:

a refrigerant charge of the vapor compression loop comprises at least 90% by weight propane.

10. The refrigerated transport system of claim 1, wherein:

a heat transfer fluid of the heat transfer loop comprises at least 50% carbon dioxide, by weight.

11. The refrigerated transport system of claim 1, being an intermodal shipping container, wherein:

the one or more doors are at a first end (28A, 28B); and

the equipment module (26) is at a second end of the body opposite the first end.

12. The refrigerated transport system of claim 11, wherein:

the pump is on the refrigerated compartment side of the wall.

13. The refrigerated transport system of claim 1, further comprising:

one or more flame arrestors across one or more openings of the equipment module.

14. The refrigerated transport system of claim 13, wherein:

said openings are along the front of the equipment module.

15. The refrigerated transport system of claim 13, wherein:

the one or more flame arrestors comprise metallic wire mesh or perforated mesh.