Apparatus for Cooling Systems

This invention relates to apparatus and methods for detecting the escape of fluids (e.g. liquids and gases) from a passage. In particular, although not exclusively, this application relates to apparatus and methods for detecting the escape of a heat transfer fluid from a cooling system / heat exchanger, such as may be used for cooling information technology (IT) servers.

Improvements in semiconductor technology have allowed manufacturers to double the number of transistors in a microprocessor roughly every 18 to 24 months since 1965. , As the number of transistors increases, the heat dissipated during microprocessor operation also increases. This problem has been further exacerbated by the recent development of blade servers, which sit vertically rather than horizontally in cabinets, and therefore can be packed in at a far higher density.

As a result, traditional IT cooling systems, such as all air or combination water / air systems (water being the primary coolant and air being the secondary coolant), are unable to absorb and transfer the excess heat generated by these new microprocessors. Furthermore, adaptation of such traditional cooling systems has proved impractical due to size, weight, noise and cooling capacity constraints.

In order to increase the heat transfer capacity of cooling systems for use in high heat gain applications of IT equipment, cooling systems have been produced that employ volatile fluids rather than air or air / water as the heat transfer fluid. Volatile fluids, such as carbon dioxide, provide a very energy efficient means of cooling, and so can cool cabinets having a much higher heat load than would be possible using traditional systems. They also provide an opportunity to save energy, especially when compared to propelling large volumes of air through a piece of equipment, and they only require relatively narrow diameter pipes to operate, so saving space. Such a cooling apparatus is described in our co-pending GB patent application no. 0421232.0.

Volatile fluids, such as carbon dioxide, are generally electrically benign and so may be used safely in such applications, despite the very high pressures - over 50 Bar for carbon dioxide - which are needed to obtain adequate cooling. However, when carbon dioxide (or another volatile fluid) is contained at such high pressures, the parts of the apparatus containing it are subject to greater levels of strain than conventional water coils / heat exchangers and therefore, potential failure and resultant escape of fluid, is a greater issue for these systems.

IT equipment is often housed in confined spaces and required to operate 24 hours a day, 7 days a week. Hence, the monitoring of degradation or failure of IT cooling systems is critical for: (a) averting catastrophic damage to the IT equipment due to over-heating, in the event of a local failure in a cooling

system; and (b) implementing strategies for maintaining operations and recovery actions.

In addition to the potential risk to IT equipment; in the event of a fluid leak, carbon dioxide can also present a health and safety issue, if adequate precautions are not taken. Whilst the quantities of carbon dioxide are small, it is volatile, used at high pressure, and often in confined or small spaces.

The main hazards associated with the use of carbon dioxide at high pressure are: (a) its asphyxiation properties; and (b) the very low local temperature associated with the escaped fluid (which may affect people or equipment in the vicinity).

Therefore, (whilst it is not intended that the present invention should be a substitute for the general area carbon dioxide monitoring and safety systems used to meet health and safety requirements for rooms where carbon dioxide is being used), a need exists for the effective monitoring of cooling systems for apparatus such as IT equipment.

Although this problem has been discussed in relation to IT systems, it is also relevant to monitoring other systems that operate using compressed, volatile and / or hazardous fluids, such as heating and cooling apparatus and storage tanks, e.g. boilers, refrigerators, etc.; especially those used on an industrial scale or where a leak could be potentially dangerous to people or equipment.

Accordingly, the present invention provides an apparatus for detecting the escape of a fluid from a cooling system having a passage, comprising:

a housing defining a volume abutting one or more portions of said passage; and

sensor means adapted to detect the presence of said fluid within said volume;

wherein the housing is adapted to collect the escaped fluid such that the sensor can detect the escaped fluid before the operation of the cooling system is compromised.

This invention recognises that by collecting any escaped fluids in a relatively small volume compared to the surface area of the passages or pipes abutted by the volume, any such fluid escape is more likely to be detected rapidly, and before the operation of the cooling system / heat exchanger is compromised.

The invention further provides a cooling system or a heat exchanger comprising the apparatus of the invention. In another aspect of the invention there is provided a monitoring system comprising the apparatus of the invention. In yet another aspect of the invention there is provided a computer installation comprising the apparatus of the invention.

Aspects of this invention may comprise apparatus wherein the housing abuts a portion of the passage or pipe that is under a locally elevated level of

mechanical stress. By targeting the portions of the passages or pipes of a cooling system / heat exchanger that are potentially most prone to failure, any failure due to escape of heat exchange fluid can be rapidly detected, i.e. before the operation of the cooling system / heat exchanger is compromised.

The invention also relates to a method for detecting the escape of a fluid from a cooling system / heat exchanger having a passage containing the fluid, comprising the steps of: defining a first volume containing one or more portions of said passage; and detecting the presence of said fluid in said first volume by indirect or direct means. Furthermore, there is disclosed a method for detecting the escape of a fluid from a portion of a passage or pipe in a cooling system or heat exchanger containing the fluid, using the apparatus of the invention.

In preferred arrangements the apparatus is adapted to detect the presence of a gas in the volume. Preferably, the fluid in the passage or pipe of the cooling system is a gas and preferably the fluid escaping from the passage or pipe (in the event of a leak, for example) is a gas. Preferably the apparatus is adapted to detect fluid which escapes from the passage in the form of a gas. Arranging for the fluid escaping from the passage or pipe to be in the form of a gas can be particularly beneficial since consideration of the action of gravity on the escaping fluid is less important than where the escaping fluid is, for example, a liquid. In particular, the volume in which the fluid is detected can

be arranged other than beneath the passage, for example laterally adjacent or indeed above the relevant portion of the passage or pipe.

Preferably the fluid is a volatile fluid, preferably carbon dioxide.

In preferred examples the sensor is adapted to detect the presence of a volatile fluid. Preferably the fluid does not comprise water. This is particularly preferred where the cooling system is adapted to cool electronic equipment, for example computer equipment, where it is deceived to be undesirable to have water in the vicinity of the electronic equipment, in view of the perceived increased risk of electric malfunction. Thus the sensor is preferably not arranged for the detection of the presence of moisture.

Preferably the detection of the fluid does not rely on a change of state of the fluid, for example a change in pressure on evaporation of a liquid.

In preferred examples, the length of the passage or pipe of the cooling system abutting the volume is less than 50%, preferably less than 25%, 10% or less than 5% of the total length of the pipe. In some arrangements, the length of the passage or pipe abutting the volume may be less than 1% of the total length of the pipe. In some examples the volume is arranged adjacent only those (or some of those) areas of the passage or pipe for which the perceived risk of leakage is the greatest.

Embodiments of the invention will now be described, purely by way of example, with reference to the accompanying drawings, in which:

FIGURE 1 shows schematically a perspective view of a typical cooling system;

FIGURE 2 shows schematically a perspective view of a cooling system fitted with two embodiments;

FIGURE 3 shows schematically a perspective view of a cooling system fitted with two embodiments, wherein each apparatus also includes a discharge pipe;

FIGURE 4 shows schematically a perspective view of a cooling system fitted with two embodiments that are in fluid communication, and that have a common discharge pipe;

FIGURE 5 shows schematically a perspective view of a cooling system fitted with three embodiments, each of which is fitted with a discharge pipe;

FIGURE 6 shows schematically a perspective view of a cooling system fitted with three embodiments, two of which are in fluid communication and share a common discharge pipe; and

FIGURE 7 shows schematically a perspective view of a cooling system fitted with three embodiments, wherein each apparatus is in fluid communication with the others and all share a common discharge pipe.

Cooling Systems and Heat Exchangers

Cooling systems and heat exchangers are designed to absorb heat from a first zone that it is desirable to cool and to dissipate the absorbed heat in a second zone where it is safe and desirable to do so. Cooling systems include freezers, refrigerators, and air conditioning units.

Typically, IT / computer cooling equipment comprises a circuit for a heat transfer fluid containing a condenser and an evaporator. The apparatus described herein is particularly useful for monitoring and detecting the escape of fluid from such equipment, especially wherein the heat transfer fluid is a volatile fluid, such as carbon dioxide. Such a cooling apparatus is described in our co-pending GB patent application no. 0421232.0.

In such apparatus, the heat exchange fluid is kept under high pressure. Typically, at above 25 bar, above 50 bar, above 75 bar or even at above 100 bar. The apparatus described herein is suitable for detecting the escape of fluid from all such systems.

Figure 1 depicts a typical cooling system that may suitably take advantage of the embodiments described herein. The cooling system contains a heat transfer circuit comprising a passage or pipe – generally of copper construction - that allows the heat exchange fluid to circulate around the system so that it is able to absorb heat energy generated by the IT equipment at a first zone and discharge heat energy at a second zone where the heat will not be reabsorbed by the IT equipment. A stream of air (indicated with an arrow) helps to remove heat from the system in the downstream direction.

As used herein the term "passage" means any suitable means that is adapted to permit the movement of fluid (e.g. a gas or a liquid) either by diffusion or otherwise (such as under a mechanical force), and may include joints, valves, attachments etc. Preferably, a passage is a pipe.

The passage or pipe has a number of portions of differing construction. As used herein, a "portion" of a passage / pipe means a longitudinal length of pipe, which may be relatively short (for example, approximately 1 cm or more, such as 2, 3, 5, 10 cm or more), or may be relatively long (for example, approximately 1 m, 2, 3, 5, 10 m or more). A portion of a pipe may comprise a relatively minor proportion of the overall length of the pipe (for example, 0.01% or more, such as 0.1, 0.5, 1% or more), or may comprise a relatively major proportion of the overall length of pipe (such as 10% or more, e.g. 20, 50, 75, 90% or more). Also, as used herein, a portion of a pipe may include

the longitudinal region across a joint or point of attachment, such that said portion comprises longitudinal lengths of two or more pipes / passages which are physically connected to each other.

For example, with reference to Figure 1, separate portions of a pipe used in a typically cooling system include; U-bends 1, which connect adjacent flow and return pipes 2. Passages or pipes may be connected to further passages / pipes at connections 3.

All pipes used in such cooling systems are subject to production tests using at least 1.5 times working pressure (e.g. up to150 bar) to ensure that the product is leak free when manufactured. However, prolonged use under conditions where the pipes are subject to high stress due to the compressed heat exchange fluid contained within could eventually cause a leak to appear. A leak that allows the escape of fluid from the passage or pipe may be caused by, for example, a loose or damaged joint, a crack or fracture in the passage / pipe, or a hole.

We have recognised that passages and pipes are most at risk of developing a leak at portions of relative weakness, or where the apparatus has suffered damage. We have recognised that in such portions, this risk can occur at pressures below, perhaps well below, those where the risk has previously been recognised, particularly in straight passages or pipes.

Testing of a complete coil / heat exchanger to destruction by progressively increasing the fluid pressure has shown that the first critical location is the outside area of a copper pipe U-bend, which ruptured at a pressure of 240 bar. Up to these pressures there was no failure of the portions of straight pipes or the flow and return connections at the entry and exit from the coil / heat exchanger.

Thus, the portions of passages / pipes that are most at risk of developing a leak are; in order of decreasing risk:

(1) The U-bends 1 or other portions that contain angles or bends;

(2) The flow and return connections to the passages / pipes 3, where one portion of a pipe is connected to another; and

(3) The straight portions of the passage / pipe within the coil / heat exchanger 2.

The regions we have identified are likely to be most at risk of developing a leak because they either contain portions that are inherently less strong than the average strength of the pipe; e.g. a joint may be less able to form an air-tight seal, or may be less able to resist the stress exerted on it by the pressurised fluid inside, in comparison to a single length of pipe (of comparable material). Similarly, portions of a pipe that are not straight; e.g.

that contain an angle or curve may be: (i) inherently stressed due to the bend or angle; and (ii) subjected to increased stress by the compressed gas, compared to a straight portion of pipe. Consequently, the straight portions of the pipes 2 are least at risk of leakage, unless damaged by an external force.

In general, the portions of pipe that are most at risk of failure are either subject to elevated levels of stress compared to the average level of stress in / on the passage; or contain regions of reduced or variable strength (resilience to force) compared to the average strength of the passage, such as the strength of the passage / pipe in straight, uninterrupted portions. This leads to a greater strain in these portions, and so a greater risk of rupture / failure.

By "stress" as used herein, it is meant any force per unit area exerted on the inside or outside of the portion of passage / pipe by means of the fluid contained inside the pipe, or any external forces that may be exerted onto the portion of pipe. Generally, by "stress" in this context it is meant the force per unit area exerted on the internal surfaces of the passage / pipe by the compressed fluid inside the pipe.

A portion of pipe that is not straight is angled or curved by any degree in relation to the longitudinal direction of the pipe; e.g. at any degree above 0°, for example, from 0.1° to 360° or above. A coil is an example of a curved pipe having a longitudinal curve of over 360°. A pipe / passage may be considered to be angled when its longitudinal direction changes extremely sharply, for

example, forming a corner. Preferably, a curved or angled passage / pipe displays a change in its longitudinal direction of at least 30°, at least 45°, at least 60°, at least 90°, at least 120°, at least 180° or above. Most preferably, the pipe (or portion of pipe) is curved by approximately 180°; i.e. the portion of pipe contains a U-bend.

Detecting Escape of Fluid

The apparatus described herein can be used for the local monitoring of portions of the passages or pipes of apparatus such as cooling systems / heat exchangers and its associated connections, for the detection of leaks in pipes or joints, particularly at regions having increased risk of leakage.

Figure 2 depicts an embodiment wherein the U bends at each end of the cooling system are enclosed by two physically discrete housings 4, 5, one at the top of the system and one at the bottom of the system as depicted. Each of the two housings may incorporate the existing metal end plates 29 (see Figure 1) of the cooling system as one wall of the housing, or alternatively the housing can be constructed to independently enclose the U-bends. The metal end plates 29 are typically L-shaped, having holes punched out of one surface to accommodate the passages / pipes of the cooling system. In this arrangement, the housings each contain more than one portion of a pipe and at least a part of each portion is curved (i.e. a U-bend). Alternatively, however, each housing may contain 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 or more portions of (one or more) pipe, e.g. in the range of 10 to 20 portions or more.

In the embodiments described, the housing preferably defines a volume abutting portions of the passages or pipes of a cooling system / heat exchanger that are most prone to failure. Thus, any such failure due to escape of heat exchange fluid can be rapidly detected, i.e. before the operation of the cooling system / heat exchanger is compromised. Moreover, by collecting any escaped fluids in a relatively small volume compared to the surface area of the passages or pipes abutted by the volume, any such fluid escape is more likely to be detected rapidly, and before the operation of the cooling system / heat exchanger is compromised.

Accordingly, a function of the housing is to collect any escaped fluid before it can dissipate or diffuse into the atmosphere. Therefore, the dilution of escaped fluid into the atmosphere is retarded by the housing to such an extent, and for a period of time sufficient, to enable the sensor to detect the escaped fluid. This will allow, for example, the implementation of strategies for maintaining operations and recovery actions. Thus, the design of the housing is adapted to suit the properties of the sensor used in the particular embodiment. Furthermore, the housing is adapted to allow the sensor to detect the escape of fluid before the amount of fluid that has escaped reaches a level at which the operation of the cooling system / heat exchanger is compromised. In a preferred embodiment the housing is substantially air-tight, in that there is virtually no free movement of fluid between the volume enclosed by the housing and the atmosphere.

In particularly preferred embodiments the surface area to volume ratio of the surface area of the portion(s) of pipe(s) enclosed by the housing to volume enclosed by the housing abutting the portion(s) of pipe(s) enclosed is small, e.g. 1 : 30. Preferably, the surface area to volume ratio is less than 1 : 1000, less than 1 : 500, less than 1 : 100, or less than 1 : 50. More preferably, the ratio is in the range of 1 : 50 to 1 : 1, still more preferably in the range of 1 : 50 to 1 : 10, even more preferably in the range of 1 : 40 to 1 : 20; and most preferably in the range 1 : 35 to 1 : 25.

In a particularly preferred embodiment, as depicted in Figure 2, the housing defines a volume abutting a series of U-bends in relatively close proximity, such that the surface area of pipe to volume ratio of housing can be minimised.

Sensors 6 and 7 are mounted onto each housing and are adapted to monitor the physical and / or chemical properties of the volume defined by the inside wall of the housing and the outside surface of the portion of pipe (the first volume). However, the sensors can equally be positioned remotely from the apparatus. The sensors are adapted to detect the presence of heat exchange fluid inside the above-mentioned first volume, by direct or indirect means, or a combination of both. For instance, each sensor may detect changes in any one of, or a combination of, or all of the following properties:

(a) presence of heat exchange fluid (for example, presence of carbon dioxide);

(b) local temperature (for example, release of compressed volatile fluid may result in an immediate fall in local temperature);

(c) local pressure (for example, escape of fluid at high pressure i.e. at above atmospheric pressure in the pipe can result in a pressure increase inside the housing).

In the above example, (a) represents a "direct" means of detection, for instance, the sensor may monitor the concentration of the particular fluid inside the housing, or may detect the fluid by means of a chemical reaction / effect caused by the presence of the particular fluid at a particular concentration. Points (b) and (c) above are examples of "indirect" means of detecting the presence of the fluid, because the effects of the escaped fluid are detected, rather than the fluid itself.

Preferably, the sensor is adapted to signal to an alarm means, such as an audio and / or visual means of attracting attention or alerting an operator to the fact that escaped fluid has been detected. The sensor may alternatively, or in addition, signal to a data storage or data processing means, such as a computer installation, or other IT equipment, to monitor and record the data received and to alert an operator, if necessary, by alarm or other communication means (such as telecommunication). The sensor or

monitoring or data processing means may also activate or cause to be activated any manual or automated remedial action systems, as designed.

The sensor may be mounted inside the housing, or may be positioned elsewhere (i.e. remotely), provided it is adapted to monitor the volume enclosed by the housing.

In a further embodiment, particularly suited to monitoring the straight pipes of the coil / heat exchanger, a sensor or set of sensors (for example, trace temperature sensing means) can be adapted to monitor the volume abutting the straight pipe sections 2, for example, by mounting a sensor or set of sensors 30 to the downstream edges of the coil / heat exchanger fins. In this way, the whole discharge area of the coil between the top enclosure 4 and the bottom enclosure 5 can be monitored. For example, at least 90% of the straight portions of passage / pipe in the heat exchanger abut the volume defined by the housing. Preferably, at least 92%, at least 95%, at least 98%, or at least 99% of the straight portions of passage / pipe in the heat exchanger abut the volume defined by the housing. Most preferably in this embodiment, 100% of the straight portions of passage / pipe in the heat exchanger abut the volume defined by the housing.

Figure 3 depicts an embodiment wherein each housing 4, 5, is adapted to connect to a discharge pipe 8, 9, such that the first volume enclosed by the housing may be in fluid communication with one or more additional volumes.

Such "additional volumes" may be enclosed / defined by additional housings (as already described), but an additional volume may also include the volume enclosed or defined by additional, physically discrete storage means (e.g. for collecting escaped gas). An additional volume may be a much larger volume / space into which it is safe to release the fluid. By "safe" it is meant that the release of the fluid into that volume or space will not cause an unacceptable risk of harm to either animal life or the environment in general. A safe space may be the atmosphere; however, if the fluid is particularly toxic it may be necessary to collect it in an alternative, preferably air-tight storage medium.

By "physically discrete" it is meant a volume or equipment that is spatially / physically separated from another volume or equipment, but which may be connected, for example, by a means of fluid communication, such as a pipe. In an alternative to the embodiment depicted in Figure 3, the sensors 6, 7, may be mounted remotely in the discharge pipes 8 and 9.

In such an embodiment where the volume inside a housing is in fluid communication with an additional volume, such as by means of a discharge pipe, if a sensor is adapted to detect a change in pressure in the first volume, then the discharge pipe can be fitted with a valve 10, or other suitable orifice plate or restriction to provide a pressure differential for sensing purposes.

The embodiment depicted in Figure 4 shows a pair of physically discrete housings that are in fluid communication with each other by means of a pipe 14. In such an embodiment it is not always necessary for each housing to be provided with its own sensor. For example, one sensor 12 or set of sensors may be provided in only one or in both housings. Alternatively, one sensor or one set of sensors may be located in the interconnecting pipe.

The pipe connecting the two housings may additionally include means of connecting to other apparatus or means for permitting fluid communication with additional volumes. Such a means may include a T-connection 13 to allow the safe discharge of the escaped volatile fluid into a safe space or the atmosphere. Again, in this embodiment, if a sensor is adapted to detect a change in pressure, then a valve or other suitable orifice plate or restriction 10 may be fitted inside the discharge pipe or connecting pipe to provide a pressure differential for sensing purposes. In such an embodiment one sensor or one set of sensors may be located in the T-connection pipe 13.

The apparatus described herein is particularly useful for detecting the escape of fluid from a point of attachment or a joint between pipes. There are a number of reasons why a portion of pipe may comprise a point of attachment or a joint, such as to connect the flow and return pipes of the cooling system / heat exchanger and the high or low level pipe work 18 that provides the volatile fluid (e.g. the carbon dioxide) to each cooling system, that distributes it between separate systems, and that removes it from the system.

There are several ways in which these points of attachment / joints may be formed. For instance, if the cooling system / heat exchanger is located on a fixed panel then the connections / joints may be hard piping with suitable unions, or flexible pipes with suitable unions. If however the cooling system is located on, for example, a door, which swings open for access, then the connections may be flexible pipes with suitable unions or purpose designed connections located approximately in line with the door hinges, to provide sealed assemblies of fixed pipes with rotary knuckle joints to accommodate the door movement. A consequence is that such joints / points of attachment are more susceptible to leaks than uninterrupted straight piping.

The embodiment of Figure 5 further comprises a housing adapted to contain a portion of pipe that includes a point of attachment or connection / a joint. The joint depicted in this embodiment is the point of attachment between the flow and return pipes of the cooling system / heat exchanger and the high or low level pipe work that provides the volatile fluid and that removes it from the system.

A housing 15 contains a portion of pipe that includes the flow and return connections / joint 3 (as described above), with the sensor 16 employed to detect escaped fluid by indirect (e.g. temperature and / or pressure change) or direct (e.g. chemical composition / concentration) means.

The embodiment depicted also has a discharge pipe 17 provided with a valve 19, to allow the volume inside the housing to communicate with the atmosphere or another volume, such as a safe space. The discharge pipe 17 may also incorporate a remote sensor for detecting the presence of heat exchanger fluid.

In an alternative embodiment a portion of the flow pipe that carries fluid to the cooling system and a portion of the return pipe that carries fluid from the cooling system may be contained in two physically discrete housings, which may be in fluid communication with each other.

In the embodiment of Figure 6, the housing containing a portion of the flow and return pipes 16 is in fluid communication via pipe 20 to a physically discrete housing 12 that encloses a plurality of U-bends in portions of pipe at the bottom of the cooling system depicted. In such an arrangement one sensor or one set of sensors 21 located in any one of the two housings or in the interconnecting pipe can be employed. Alternatively, sensors can be adapted to monitor each enclosure.

The connecting pipe 20 is also fitted with a T-connection and discharge pipe 22 to permit safe discharge of escaped fluid to another safe area or to the atmosphere. Again, the pipe 22 may be fitted with a valve 23 to regulate movement of fluid in the discharge pipe, particularly if the sensor(s) is / are adapted to detect changes in pressure.

In an alternative embodiment to that depicted, the discharge pipe 22 may alternatively or additionally incorporate a remote sensor for detecting the presence of heat exchanger fluid.

Figure 7 shows an embodiment in which top 4, bottom 5 and flow and return 16 housings are in fluid communication via pipes 24. This allows the use of one sensor or one set of sensors to detect escape of fluid from any one on the portions of pipe that are contained in the three housings. For example, one sensor or a set of sensors may be adapted to monitor the escape of fluid at one or more of positions 25 or 26.

In the embodiment depicted, the interconnecting pipe 24 is fitted with a T-connection and discharge pipe 27 having a valve 28, to permit safe discharge of any volatile fluid such as carbon dioxide to a safe area or to the atmosphere.

In an alternative embodiment, the discharge pipe 27 may also / alternatively incorporate a remote sensor for detecting the presence of heat exchanger fluid.

The apparatus disclosed herein also allows for methods for detecting the escape of fluid from a portion of a passage or pipe, such as from a pipe of a

cooling system or heat exchanger, by using the apparatus disclosed herein, as described hereinbefore.

The person of skill in the art will appreciate how the apparatus and methods described herein may also be suitable for detecting the escape of a fluid, such as a volatile fluid (e.g. carbon dioxide) from an apparatus other than a cooling system or heat exchanger, such as a gas storage tank etc.

CLAIMS:

1. Apparatus for detecting the escape of a fluid from a cooling system having a passage, comprising:

a housing defining a volume abutting one or more portions of said passage; and

sensor means adapted to detect the presence of said fluid within said volume;

wherein the housing is adapted to collect the escaped fluid such that the sensor can detect the escaped fluid before the operation of the cooling system is compromised.

2. Apparatus according to Claim 1, wherein said fluid is a volatile fluid.

3. Apparatus according to Claim 2, wherein said fluid is carbon dioxide.

4. Apparatus according to any of Claims 1 to 3, wherein the sensor is adapted to detect the presence of a gas.

5. Apparatus according to any of claims 1 to 4, wherein the apparatus is adapted to detect fluid which escapes from the passage in the form of a gas.

6. Apparatus according to any of Claims 1 to 3, wherein the sensor is adapted to detect the escape of fluid into said volume by indirect or direct means.

7. Apparatus according to Claim 6, wherein said indirect means is a change in pressure within the volume.

8. Apparatus according to Claim 6, wherein said indirect means is a change in temperature within the volume.

9. Apparatus according to Claim 6, wherein said direct means is a chemical change such as a change in chemical concentration in the volume.

10. Apparatus according to any preceding claim, wherein said sensor is located remotely to said housing.

11 Apparatus according to any preceding claim, wherein said passage is a pipe and said one or more portions of a passage is one or more portions of a pipe.

12. Apparatus according to any of Claims 1 to 11, wherein said cooling system comprises a heat exchanger comprising said passage or pipe.

13. Apparatus according to any preceding claim, wherein the ratio of the surface area of said one or more portions of passage or pipe to the volume defined by said housing abutting said one or more portions of passage or pipe is less than 1 : 100.

14. Apparatus according to Claim 13, wherein the surface area to volume ratio is less than 1 : 50.

15. Apparatus according to Claim 13, wherein the surface area to volume ratio is in the range 1 : 50 to 1 : 10.

16. Apparatus according to Claim 13, wherein the surface area to volume ratio is in the range 1 : 40 to 1 : 20.

17. Apparatus according to Claim 13, wherein the surface area to volume ratio is in the range 1 : 35 to 1 : 25.

18. Apparatus according to Claim 13, wherein the surface area to volume ratio is approximately 1 : 30.

19. Apparatus according to any preceding claim, wherein the housing abuts a portion of the passage or pipe that is under a locally elevated level of mechanical stress.

20. Apparatus according to any preceding claim, wherein the housing abuts a portion of the passage or pipe that is curved or angled in the longitudinal direction of the pipe.

21. Apparatus according to Claim 20, wherein said curve or angle is at least 30°.

22. Apparatus according to Claim 20, wherein said curve or angle is at least 60°.

23. Apparatus according to Claim 20, wherein said curve or angle is at least 120°.

24. Apparatus according to Claim 20, wherein said curve or angle is at least 180°.

25. Apparatus according to any preceding claim, wherein at least a one of said one or more portions of a passage or pipe is curved at an angle of approximately 180° (e.g. a U-bend).

26. Apparatus according to any of Claims 1 to 19, wherein said sensor is adapted to monitor straight portions of passage / pipe.

27. Apparatus according to Claim 26, wherein said sensor is adapted to detect a change in temperature within the volume.

28. Apparatus according to Claim 26 or Claim 27, wherein said sensor is mounted on the downstream edge of the coil / heat exchanger fin.

29. Apparatus according to Claim 28, wherein the volume defined by said housing abuts substantially all of the straight portions of passage / pipe in a heat exchanger.

30. Apparatus according to any preceding claim, wherein the volume defined by said housing abuts one or more portions of a passage or pipe having a joint.

31. Apparatus according to any preceding claim, wherein the housing contains 2 or more portions of said passage or pipe.

32. Apparatus according to any preceding claim, wherein the housing contains 10 or more portions of said passage or pipe.

33. Apparatus according to any preceding claim, wherein the housing contains 10 to 20 portions of said passage or pipe.

34. Apparatus according to any preceding claim, wherein the length of the passage or pipe of the cooling system abutting the volume is less than 50%, preferably less than 25% or more preferably less than 10% of the total length of the pipe.

35. Apparatus according to any preceding claim, wherein said volume is in fluid communication with one or more spaced apart additional volumes.

36. Apparatus according to Claim 35, wherein the means of fluid communication is a discharge or connecting pipe.

37. Apparatus according to Claim 36, wherein said discharge or connecting pipe is provided with a valve to regulate the rate of fluid communication between said one or more additional volumes.

38. Apparatus according to Claim 36 or Claim 37, wherein the sensor is mounted on or in said discharge or connecting pipe.

39. Apparatus according to any of Claims 35 to 38, wherein said one or more additional volumes are defined by one or more additional housings.

40. Apparatus according to any of Claims 35 to 39, wherein one or more of said additional volumes is a safe space, such as an air-tight storage means or the atmosphere.

41. Apparatus according to any preceding claim, comprising a plurality of housings as defined in any preceding claim.

42. Apparatus according to any preceding claim, comprising two or more sensors as defined in any of Claims 1 to 10.

43. Apparatus according to Claim 42, wherein each of said two or more sensors is adapted to detect the escape of fluid by the same or by different indirect or direct means.

44. Apparatus according to any preceding claim, adapted to signal to an alarm means.

45. Apparatus according to any preceding claim, further comprising an alarm means.

46. Apparatus according to any preceding claim, adapted to signal to a data storage or processing means.

47. Apparatus according to Claim 46, wherein said data storage or processing means is a computer installation.

48. Apparatus according to Claim 46, wherein said data storage or processing means is a monitoring system.

49. Apparatus according to any preceding claim, wherein said housing defines a volume abutting a series of U-bends.

50. Apparatus substantially as described herein and / or as depicted in the accompanying figures.

51. A cooling system comprising the apparatus of any of Claims 1 to 50.

52. A heat exchanger comprising the apparatus of any of Claims 1 to 50.

53. A monitoring system comprising the apparatus of any of Claims 1 to 50.

54. A computer installation comprising the apparatus of any of claims 1 to 50.

55. A method for detecting the escape of a heat exchange fluid from a cooling system or heat exchanger using the apparatus of any of Claims 1 to 50.