

## A VDR Capsule Unit

### FIELD OF INVENTION

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The present invention relates broadly to a voyage data recorder unit.

### BACKGROUND

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Similar to the "black box" flight recorders for aircraft, voyage data recorders (VDRs) are used for recording relevant information of ships to facilitate investigation of accident or maritime incidents for ships or more generally for water bound vessels.

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Under regulations from the International Maritime Organisation (IMO), passenger ships and ships other than passenger ships of 3000 gross tonnes and upwards constructed on or after 1 July 2002 must carry VDRs to assist in accident investigations, under regulations adopted in 2000 which entered into force on 1 July 2002. Performance standards for VDRs were adopted in 1997 and provide details on what type of data is to be recorded, and general VDR specifications. For example, the standards provide that the VDR should continuously maintain sequential records of pre-selected data items relating to status and output of the ship's equipment and command and control of the ship.

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Generally, the VDR is installed in a protective capsule or boiler, which is typically brightly coloured to facilitate visual location, and should be fitted with an appropriate device to aid location, such as a beacon device. Typically, the VDR installed in the protective capsule will be fitted on the deck area of the ship, to ease recovery and to maximize the probability of survival after an incident. The relevant data is supplied and continuously maintained in sequential records via suitable connections between the VDR and relevant equipment on the ship, in particular within the command bridge. Typically, a VDR is installed in conjunction with a main unit installed at the command bridge or proximate to the relevant equipment from

which data is to be collected. The main unit controls and facilitates the upload of the relevant data to the VDR for the continuous maintaining of the sequential records of the relevant data.

5           The overall VDR system, including the Final Recording Medium installed in the protective capsule, and any associated main unit, are subjected to periodic performance tests, and new VDR systems have to undergo a certification process under the IMO.

10           In the design of VDRs installed in a protective capsule, certification is related to meeting certain environmental conditions for specified ranges. For example, currently one of the specifications is that data storage in the VDR must be able to withstand 260°C for 10 hours and 1100°C for 1 hour. As such, a number of existing designs for VDRs installed in a protective capsule have been proposed. In one such  
15 design described in CA2361797A1, a boiler including a bifurcated cylindrical member, one portion of which is a thermal expansion cavity adapted to contain a phase change material or thermal mass which acts as a heat sink, is used. The other portion of the bifurcated cylindrical member defines a storage compartment for a stack memory. The two portions are separated by a demising wall, which includes  
20 a fusible valve which opens at a predetermined temperature to allow the thermal mass to enter the storage compartment to protect the stack memory from fire. However, one disadvantage associated with that design is that the majority of practical water-based thermal masses, including "plain" water, may damage or more generally affect the integrity of the stack memory. Furthermore, such water-based  
25 thermal masses typically undergo a phase change at the specified temperature of 260°C or 1100°C, resulting in pressure built up within the boiler, which again can negatively affect the integrity of the stack memory.

          Another challenge with existing designs for VDRs installed in a protective  
30 capsule is to provide a means for identifying from the recovered VDR, whether the memory component has been subjected to conditions which, while not entirely destroying the memory component, may have adversely affected the integrity of the stored data.

A need therefore exists to provide a VDR installed in a protective capsule that seeks to address at least one of the above mentioned problems.

## **SUMMARY**

In accordance with an aspect of the present invention, there is provided a VDR capsule unit comprising: a capsule; a first chamber disposed inside the capsule, the first chamber being encapsulated by an adiabatic material; a data storage component disposed inside the first chamber; a thermal mass liquid disposed inside the first chamber; a vent mechanism for venting gas or steam from the first chamber when a temperature ambient around the capsule causes a phase change in the thermal mass liquid; and wherein the data storage component is disposed inside a second chamber disposed in the first chamber, and wherein the second chamber seals the data storage component from direct contact with the thermal mass liquid.

The vent mechanism may comprise a valve unit in fluid communication with the first chamber.

The valve unit may comprise a material chosen such that in a solid state of the material, said fluid communication is closed, and such that in a melted state of the material at a temperature at which said phase change of the thermal mass liquid occurs, said fluid communication is open.

The unit may further comprise a vent pipe in fluid communication with the valve unit, the vent pipe being arranged for venting of the gas or steam.

The vent pipe may be in fluid communication with an opening for venting of the gas and steam, the opening comprising a further material chosen such that in a solid state of the further material, said opening is closed, and such that in a melted state of the further material when said phase change of the thermal mass liquid occurs, said opening is opened.

The unit may further comprise an indication material member on the second chamber, wherein the indication material member is chosen such that it undergoes a permanent shape change when exposed to a temperature above a pre-determined safety level, for indicating exposure of the data storage component to said temperature above the safety level upon recovery of the unit.

The unit as claimed may further comprise a base structure for mounting the unit to an external structure, and one or more locking mechanisms for releasably locking the capsule to the base structure, wherein the locking mechanisms are lever-based such that sideways and downward motion of handles coupled to levers of the respective locking mechanisms releases the capsule from the base structure.

The unit may further comprise one or more wires disposed such that each wire is broken when the respective locking mechanisms are opened, for tamper proofing the unit.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will be better understood and readily apparent to one of ordinary skill in the art from the following written description, by way of example only, and in conjunction with the drawings, in which:

Figure 1 is a schematic cross-sectional drawing of a VDR capsule unit according to an example embodiment.

Figure 2 shows an exploded view of the VDR capsule unit of Figure 1.

Figure 3 shows a perspective top view of the VDR capsule unit of Figure 1.

Figures 4a to d show side views of the VDR capsule unit of Figure 1, illustrating unlocking of the capsule from the capsule base.

Figure 5 is a schematic cross-sectional drawing of a detail of the VDR capsule unit of Figure 1.

#### DETAILED DESCRIPTION

The described example embodiment provides a design for a VDR installed in a protective capsule in which a water or water-based thermal mass is utilised for protecting the data storage component, while facilitating release of vapour or steam resulting from a phase change of the thermal mass to prevent or reduce damage to the data storage component. Furthermore, in the described design direct contact between the data storage component and the water-based thermal mass is prevented. Furthermore, in the described design, means are provided to identify whether or not the data storage component was subjected to a temperature above a pre-defined safety level that may result in untrue or inaccurate data captured by the data storage component in the recovered VDR.

Figure 1 shows a cross-sectional drawing of a VDR capsule unit 100 in the described example. The unit 100 comprises a capsule 102, which is provided with a bright coloured coating at an external surface thereof. The capsule 102 is made from S/S304 [Stainless Steel 304] in the described example.

An adiabatic material 104 is provided inside the capsule 102. In the described example, the adiabatic material is WDS Flexipor. A can 106 is encapsulated within the adiabatic material 104 and position centrally within the capsule 102. A capsule base 108 is provided for mounting the unit 100 onto an external surface of a ship, such as on the external roof structure of a command bridge of a ship. Wire connection clips 110 are provided within the capsule base 108 for facilitating connection of suitable wires (not shown) for data transfer to a final recording medium 112 of the VDR capsule unit 100. Figure 2 shows an exploded view of the VDR capsule unit 100, rotated by 90° compared to Figure 1. Respective cable connections 200, 202 and 204 are provided for data transfer to the final recording medium 112. A sealed cable coupling 206 is provided in a sidewall of the capsule base 108, with a male/female cable coupling 208 provided at a cable housing 210 secured on the capsule 102. The housing 210 is received inside the capsule base 108 when the capsule 102 is mounted to the capsule base 108. In the described example, there are two lines for data transmit, two lines for data receive and two power lines providing +24V in each of the cables 200, 202, and 204.

Turning now to Figure 3, which shows a perspective top view of the VDR capsule unit 100, two locking mechanisms 114, 116 are provided at opposing portions of the cylindrical capsule 102, to releasably connect the capsule 102 to the capsule base 108 for recovery. In the described example, the locking mechanism 114, 116 comprises a lever base mechanism. Release handles 118, 120 are in an upward position in a locked stage of the locking mechanism 114, 116. Temper proof wires 119, 121 are fixed through openings 122, 124 of the locking levers 123, 125 respectively, in the locked position, and through openings of anker elements (hidden in Figure 3) secured to the capsule 102. As will be appreciated by a person skilled in the art, while the wires 119, 121 function as a temper proof device, they do not hinder an easy and quick release of capsule 102 from the capsule base 108, by pulling the release handles 118, 120 sideward and downwards to unlock the locking mechanisms 114, 116 respectively.

Figures 4a to d show side views of the VDR capsule unit 100, illustrating unlocking the capsule 102 from the base plate 108. First, sideward and downward movement of the release handles 118, 120 pivots the locking leavers 123, 124 away from the capsule 102 surface as illustrated in Figures 4a and b. During that movement, the temper proof wires 119, 121 (Figure 3) are broken as described above.

Further downward movement of the handles 118, 120 results in downward movement of the locking clamps 400, 402, thereby enabling release of the clamps 400, 402 from catch elements 404, 406 on the capsule base 108, and illustrated in Figures 4c and d. Upward movement of the handles 118, 120 will result in pivoting of the clamps 400, 402 away from the catches 404, 406, and thus enabling upward movement of the capsule 102 for removal from the capsule base 108.

Returning now to Figure 1, the final recording medium (FRM) 112 is located inside an FRM case 126 disposed inside the can 106. An FRM case cover 128 is sealingly secured to the FRM case 126 at a bottom thereof, utilising bolts 130, 132. A mixture of water and antifreeze 134 is used as the thermal mass in the described example, and is contained within the can 106. In addition to withstanding a high temperature environment, the thermal mass is chosen to withstand low temperatures, e.g. -25°C for about 10 to 16 hours. More particular, the water and antifreeze mixture in the described example is capable of staying in a semi-solid state, similar to that of

crushed ice, in that temperature range. An air gap 135 is reserved to accommodate thermal expansion during phase changes.

5 A vent pipe 136 is incorporated in the can 106 structure, and includes a valve structure 138 disposed at a top portion of the can 106 in the described example. The valve structure 136 comprises a low temperature metal 137 which, in a solidified state, seals fluid communication between the inside of the can 106 and the vent pipe 136, via two baffle chambers 140, 142. One of the baffle chambers 140 is in fluid communication with the inside of the can 106 via a vent opening 143, whereas the other chamber 142 is  
10 in fluid communication with the vent pipe 136.

In the described example, the FRM 112 is continually immersed in the water 134, for protecting the FRM 112, but within the FRM case 126 to avoid direct contact between the FRM 112 and the water 134. This advantageously avoids exposure of the FRM to  
15 the water 134, while maintaining the thermal protection concept of immersing the FRM 112 substantially fully within the thermal mass, i.e. water 134 in the described example.

At the same time, in the described design, gases, in particular steam produced from a phase change of the water 134 above the boiling point can exit the can 106, thus  
20 preventing detrimental effects that may be caused from a pressure built up within the can 106. More particular, the low temperature metal 137, in the example embodiment, is a tin/lead alloy, is chosen such that it melts substantially at the boiling temperature of the water 134. As will be appreciated by a person skilled in the art, the low temperature molted metal becomes permeous to fluids, including gas or steam, thereby enabling the  
25 steam to exit the can 106 via the valve structure 138 and the vent pipe 136.

The vent pipe 136 terminates at the base 146 of the capsule 102. The gas or steam is thus fed into the internal volume between the capsule 102 and the capsule base 108, and from there the gas or steam is vented to the outside using a vent opening  
30 148 formed in the capsule base 108. The opening 148 is stoppered by a low melting point metal 150, a tin/lead alloy in the described example, which melts on application of heat to release the expelled gas or steam. The metal 150 is chosen such that it has melted by the time temperatures are so that the gas or steam is can be discharged from the water can 106 via the vent pipe 136 and the opening 148.

A pinger 144 is secured on top of the capsule 102 using a mounting bracket 146 in the described example. As will be appreciated by a person skilled in the art, the pinger 144 is an underwater acoustic beacon, which aids in recovery of the submerged capsule 102.

Figure 5 shows a cross-sectional view of the can 106 encapsulated within the adiabatic material 104 (Figure 5) in the described example. A base portion 500 of the FRM case 126 is connected to a sidewall 502 of the cylindrical can 106. A ring-like metal piece 504 is welded to the sidewall 502 to facilitate mounting of the base portion 500 by means of screws, e.g. 506.

The FRM case cover 128 comprises electrical interconnects 506, 508 for data transfer to the FRM 112. In the described example, the FRM 112 consists of a known data storage structure such as board mounted flash memory chips.

A high temperature indication material member 510 is incorporated in the FRM case cover 128 in the described example. The material member 510 is designed to have a pre-determined shape in a normal environmental temperature range. In the described example, the material tin/lead alloy. The material is chosen such that the material member 510 will change shape permanently when subjected to a temperature above a pre-defined safety level that may result in untrue or incorrect data in the FRM 112. Therefore, upon recovery of the VDR, the material member 510 advantageously functions as an integrity indicator to determine whether or not the FRM 112 was subjected to a temperature leading to untrue or inaccurate data in the FRM 112, at any stage prior to recovery of the VDR capsule unit.

It will be appreciated by a person skilled in the art that numerous variations and/or modifications may be made to the present invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects to be illustrative and not restrictive.

**CLAIMS**

1. A VDR capsule unit comprising:
  - a capsule;
  - a first chamber disposed inside the capsule, the first chamber being
  - 5 encapsulated by an adiabatic material;
  - a data storage component disposed inside the first chamber;
  - a thermal mass liquid disposed inside the first chamber;
  - a vent mechanism for venting gas or steam from the first chamber when a
  - temperature ambient around the capsule causes a phase change in the thermal
  - 10 mass liquid; and
  - wherein the data storage component is disposed inside a second chamber
  - disposed in the first chamber, and wherein the second chamber seals the data
  - storage component from direct contact with the thermal mass liquid.
- 15 2. The unit as claimed in claim 1, wherein the vent mechanism comprises a valve unit in fluid communication with the first chamber.
3. The unit as claimed in claim 2, wherein the valve unit comprises a
- material chosen such that in a solid state of the material, said fluid communication is
- 20 closed, and such that in a melted state of the material at a temperature at which said
- phase change of the thermal mass liquid occurs, said fluid communication is open.
4. The unit as claimed in claim in claims 2 or 3, further comprising a vent
- pipe in fluid communication with the valve unit, the vent pipe being arranged for
- 25 venting of the gas or steam.
5. The unit as claimed in claim 4, wherein the vent pipe is in fluid
- communication with an opening for venting of the gas and steam, the opening
- comprising a further material chosen such that in a solid state of the further material,
- 30 said opening is closed, and such that in a melted state of the further material when
- said phase change of the thermal mass liquid occurs, said opening is opened.

6. The unit as claimed in any one of the preceding claims, further comprising an indication material member on the second chamber, wherein the indication material member is chosen such that it undergoes a permanent shape change when exposed to a temperature above a pre-determined safety level, for indicating exposure of the data storage component to said temperature above the safety level upon recovery of the unit.

7. The unit as claimed in any one of the preceding claims, further comprising a base structure for mounting the unit to an external structure, and one or more locking mechanisms for releasably locking the capsule to the base structure, wherein the locking mechanisms are lever-based such that sideways and downward motion of handles coupled to levers of the respective locking mechanisms releases the capsule from the base structure.

8. The unit as claimed in claim 7, further comprising one or more wires disposed such that each wire is broken when the respective locking mechanisms are opened, for tamper proofing the unit.