THE DESIGN, DEVELOPMENT & TESTING OF TEXTILE VENTILATION TRANSFER DUCTING FOR WARSHIPS AND RFA'S

BY

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ABSTRACT

The engineering technology and scientific development to support material advances has taken significant strides during the last decade. As the fleet operational requirements become evermore demanding so our industry has been required to react to those needs by delivering cutting edge products that will provide the environmental conditions in which the ships crews can operate safely and efficiently. Requirements must be met at an affordable cost that has meant diversification through innovation to provide a range of new to service products and equipments that when combined can greatly improve platform atmosphere management and control. Two of the most recent developments introduced into service by Wellman Defence Ltd (WDL) are the Combined Oxygen Generation System (COGS) that will be the subject of a separate paper in the Engineering Journal for the future and the development and introduction into service of Textile Ventilation Transfer Ducting.

Introduction

This paper aims to provide the reader with an overview of recent developments for textile ventilation transfer ducting that will compliment the textile distribution ducting that was first introduced into RN service in 1996 following a period of trials and evaluation on the Seaman Training platform HINDOSTAN at the Royal Naval College, Dartmouth. The first extensive ship fit of distribution ducting was completed later that year on HMS FEARLESS and successfully trialled whilst deployed under extreme tropical conditions in the Far East, this early development work was described in a previously published paper[1] and the reader is strongly advised to source that paper for the background information that describes in some detail the concept of textile ducting.

The Need for Change

Conventional ventilation ducting is one of the most expensive ship systems to design, manufacture and fit and until very recently only a small proportion of those costs could be offset by the introduction of textile distribution ducting within the compartment(s) served. No solution existed for the replacement of conventional transfer ducting until very recently when the development of specialist non-permeable textiles enabled WDL to reappraise this situation and take an innovative whole system approach to the development of transfer ducting that can be used to replace the significantly larger proportion of the ventilation and air conditioning delivery system. Where textile transfer ducting is combined with the permeable distribution textile ducting that is now widely used throughout the fleet then the potential can be fully realised in greatly reducing the attributed manufacture and fit costs when compared with conventional ducting. Furthermore both weight and noise can also be significantly reduced. It is worthy to note that textile ventilation ducted systems can be employed to replace entire conventionally ducted systems or indeed modify them to meet with new to platform requirements, typically Alterations and Additions. New to service platforms such as Astute are also introducing these systems since it is readily recognised that they can provide significant financial benefits whilst markedly improving system efficiency and capability.

Currently the transfer of conditioned air from the Air Treatment Unit (ATU) to the compartments being served is achieved by using conventional ducting, to overcoming the degradation of the treated air during transfer, thermal insulation must be fitted. For conventional transfer ducting to be efficient the thermal insulation commonly described as “lagging” has to be applied to all of the duct external surfaces and since conventional ducting is invariably manufactured from aluminium or steel sheet then the conductivity is high and so the influence of the ambient conditions can be expected to be significant where the trunk is exposed. For extreme conditions especially where the lagging has become detached or may be incomplete then the dew point will inevitably be reached thus causing condensation to form on the exposed surface. Mineral Fibre Marine Board (MFMB) or cork materials are invariably used, both materials are costly to apply since the fitting of such materials is labour intensive and time consuming to achieve a sufficiently good fit. Cork lagging is an extremely dense material to use and it will therefore further increase the overall weight of the conventional ducted system, it is also susceptible to shock and vibration and frequently under its own weight will become detached from the surface of the ducting.

Discussion

There is very little benefit in providing a compartment with influent air that is delivered in the same condition as the re-circulated or effluent air and so development work was required to overcome the problem of thermal degradation for textile transfer ducting. The use of any conventional insulation materials to clad textile ducting was clearly impractical since textile ducting by its very nature will continually flex. The need to take an innovative approach to the problem was necessary in order to ensure that the already established advantages that existed for the distribution ducting would also continue to apply in respect of transfer ducting. It was seen as being vitally important not to compromise in any way those benefits that had seen textile systems proliferate throughout the fleet.

A series of trials were conducted using various configurations and temperature differentials to establish the rate of loss for conditioned air over a set length of textile transfer ducting. The trials were extensive and involved considerable financial and manpower resources to obtain the required and necessary data. The work had to be undertaken in a controlled laboratory environment so as to ensure that both the treated air and the ambient air could be accurately controlled and managed throughout the trials. Humidity control was also seen to be a significant contributory factor to the success of this work since there was also a need to ensure that condensation would not and could not form on the wall of the textile for extreme environmental conditions, any degradation when reaching the dew point would clearly be unacceptable for a textile ventilation system that could well be sited in a compartment containing high voltage electrical equipment.

The development work eventually led to a double walled configuration that utilises a small percentage of treated air to provide the required thermal barrier to separate the ambient air from the treated air. The inner skin of the ducting is manufactured in a permeable material that is allowed to bleed into the thermal chamber thus preventing any sudden change in condition and temperature differential that would cause condensation. The air from the thermal chamber is collected by the main stream of treated air at predetermined locations along the length of the transfer ducting so that any ambient influence is absorbed back into the conditioned airflow. As the air used for the thermal break is no more than 5% of the total volume airflow the impact on the conditioned air mixing with the air from the chamber is negligible and equates to the degradation expected for a conventional insulated ducted system having 25mm thick cork lagging applied.

Shown below is a diagram that provides the general configuration for a length of transfer ducting.

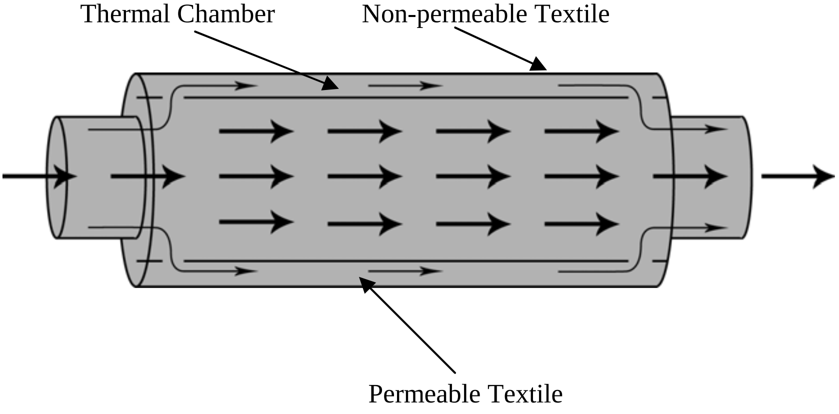

FIG.1 - DIAGRAM SHOWING AIRFLOW IN A SECTION OF TRANSFER DUCTING (NOT TO SCALE)

The textile materials used for the manufacture of the transfer ventilation ducting are in their own right state of the art products that have been developed and selected for this application as joint venture between the material manufacturer / supplier and WDL. Whilst other companies may claim to have these materials available to them, the type MSS6001 and 6005 permeable and non-permeable textiles are proprietary products.

Extensive material fire, smoke and toxicity testing has been undertaken on both MSS6001 and MSS6005 textiles to ensure that they are capable of achieving the exacting standards required by MoD (Navy). It was seen as being particularly important that this innovative application could be delivered for both SURFLOT and SUBFLOT alike, consequently the two textile types employed have both been assessed as category A1 materials in accordance with DEFSTAN 07-247 that will allow their use for the submarine application in addition to the surface fleet.

Both of these textiles are listed in the Submarine Materials Toxicity Database (SMTD) Permeable - MSS6001 is SMTD Ref A3708 and Non-permeable - MSS6005 is SMTD Ref A4008.

Provided below is a summary table showing the test results that were achieved on both textiles.

TABLE 1 - *Summary of Fire Tests[2] on Texvent Materials*

Property	**Test Method**	**Def Stan 07-247[3] target criteria**	**Permeable texvent material – MSS6001 HAF 350**		**Non-permeable texvent material – MSS6005 HAG 179**	
Smoke Index	Def Stan 02–711	<50	1.1 (~0.5 mm thick)		5.0 (~0.5 mm thick)	
Oxygen Index	BS EN ISO 4589–2	>30%	30.0 %		29.4 %	
Flammability Temperature (Temperature Index)	*BS EN ISO 4589–3* Annex A	>200 °C	374 °C		313 °C	
Elemental Composition	Lassaigne Sodium Fusion	n/a	Positive Positive Negative Negative Negative	Nitrogen Chloride Bromide Fluoride Sulphur	Positive Slight Pos Negative Negative Negative	Nitrogen Chloride Bromide Fluoride Sulphur
Toxicity Index (1 d.p.)	Def Stan 02–713	<5 (no halogens detected)	4.7 / 100 g		4.8 / 100 g	

To protect the extensive work and considerable investment in both materials and product patents have been applied for and these are provided below:

- UK Patent Application No. 0428454.3
- US Patent Application No. 11/023,510

Table 2 below is able to demonstrate that halogens were not detected in the quantative Def Stan 02-713 test. It will also be seen that no HBr, HF or HCI were present in this test for either of the materials. It is also worth noting that only small traces of HCI were recorded in the qualative Lassaigne Sodium Fusion test, see Table 1 above.

TABLE 2 - *Def Stan 02-713 Toxicity Index - Summary of Average Results for Individual Gases*

Gas	**Formula**	**Permeable Texvent material MSS6001 HAF 350**	**Non-permeable Texvent material MSS6005 HAG 179**
Carbon Dioxide	CO_2	**0.30**	**2.24**
Oxides of Nitrogen	NO_x	**4.23**	**2.39**
Carbon Monoxide	CO	0.10	**0.09**
Hydrogen Cyanide	HCN	0.00	0.00
Hydrogen Chloride	HCI	0.00	0.00
Hydrogen Bromide	HB_r	0.00	0.00
Sulphur Dioxide	SO_2	0.00	0.00
Formaldehyde	HCHO	0.00	0.00
Acrylonitrile	CH_2CHCN	**0.09**	**0.09**
Hydrogen Sulphide	H_2S	0.00	0.00
Ammonia	NH_3	0.00	0.00
Hydrogen Fluoride	HF	0.00	0.00
Phenol	C_6H_5OH	0.00	0.00
Phosgene	$COCI_2$	0.00	0.00
Toxicity Index (1 d.p.)		**4.7 / 100g**	**4.8 / 100g**

The development and production of specialist permeable and non-permeable materials for the manufacture of textile ventilation distribution and transfer ducting to meet with stringent MoD fire and toxicity requirements has contributed to ships safety, reduced system procurement costs, improved system efficiency and significantly reduced both transmitted noise and system weight. The more recent development and introduction into service of non-permeable materials have enable the manufacture of transfer ducting that will provide for even greater flexibility of design and further reductions in both cost and weight. Such benefits are clearly attractive in particular the attributed cost at times of heavy financial constraint.

Textile ventilation transfer and distribution ducting is without doubt providing the customer with a more efficient system. The reduction in transmitted noise is but one advantage that can contribute to improved communication, as an example a reduction of 6db has been achieved for the Type 23 Bridge. Permeable textile ducting also improves compartment air quality by providing a second stage of air-filtration. Reduced noise and cleaner air both greatly contribute to the improved habitability environment that in turn will enhance the operational effectiveness of a platform. Where these systems have been fitted ships staff have commented positively on the noticeable improvement in their working and living conditions.

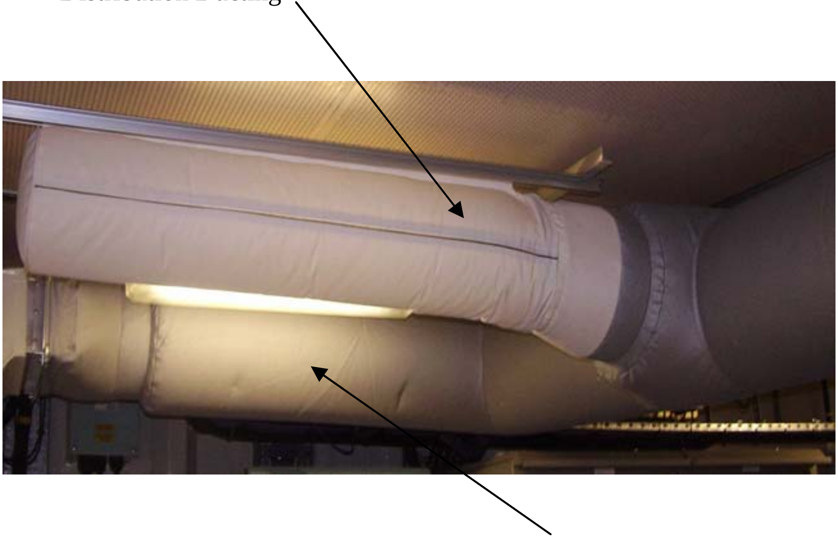

FIG.2 - HMS ALBION (LPD) - COMBINATION OF TRANSFER DUCTING AND DISTRIBUTION DUCTING WITHIN A CONDITIONED VENTILATION SUPPLY SYSTEM

In addition to the design and manufacture and fit of textile ducting, WDL are also able to provide continuous in-service support to include cleaning for these bespoke systems at the UK waterfront through the two major refit facilities with permanently based staff located at Devonport Dockyard and the Clyde Submarine Base. The company also has a member of staff collocated with the HVAC team within the MESH IPT at Abbey Wood, Bristol, to liaise and provide assistance to both EIPT, PIPT and ships staff. The recently completed state of the art company offices and factory are located at Portsmouth thus the whole of the UK naval waterfront infrastructure is within easy reach should environmental expertise be sought at short notice. The strategic location of company resources also ensures that reactive support can be readily provided to both SURFLOT and SUBFLOT alike.

FIG.3 - HMS ALBION (LPD) TEXTILE TRANSFER & DISTRIBUTION DUCTING – MCO AND ANNEX.

Summary

Realisation of the benefits and significant advantages that are offered by the use of textile ventilation ducting has seen a considerable increase in its use throughout the fleet. Textile ducted ventilation systems are now providing a level of flexibility with versatility at an affordable cost that could not be previously achieved with conventional systems.

The trend in recent years to upgrade platform capability has often adversely affected the compartment heat load particularly where additional electronic equipment has been installed without the requisite cooling. If an increase in the required cooling capacity for the host compartment conditions is not provided then environmental conditions will invariably deteriorate leading to a situation that may impact on reduced equipment reliability. In the extreme this situation could adversely affect platform operational availability.

The upgrade of ventilation supply and distribution systems at an acceptable cost through the employment of textile ducting can often obviate the associated problems described above, system design changes to make better use of the cooling capacity that is available can often eliminate hot spots, this approach may be all that is required to resolve what can be seen as an insurmountable problem.

Wellman Defence Ltd (WDL) is responsible for providing Submarine Atmosphere Purification (SAP) equipment and Heating Ventilation & Air Conditioning (HVAC) support to the Royal Navy through the Marine Environmental Survivability & Habitability Integrated Project Team (MESH IPT).

WDL is the leading UK authority and Original Equipment Manufacturer (OEM) for the suite of specialised equipment that manages the submarine environment. The company has a worldwide reputation of excellence in this field and in addition to the ongoing MoD UK (Navy) business WDL are the selected Prime and OEM for the provision of specialised atmosphere control equipment that will be integrated into the new build Barracuda French Nuclear Submarine Project.

Acknowledgements

The authors wish to acknowledge the support and assistance of the Major Warships Integrated Project Team (MW IPT) in providing the opportunity to install the first transfer textile ventilation ducting on HMS ALBION, the IPT's positive approach and belief in this innovative solution has provided ships staff with a much improved and healthier working environment.

The authors also wish to place on record the invaluable support and assistance provided by the staff of the Director of Sea Systems, Material Technology Group for their hands on approach in assisting WDL to obtain the required and necessary Fire, Smoke and Toxicity categorisation. This initiative has enabled the company to make a significant contribution to the habitability and operational effectiveness of submarines in addition to surface ships. WDL also wish to thank Sea Systems, Material Technology Group for providing the necessary permissions to publish the summary of test results.

References

1. Journal of Naval Engineering Volume 40, December 2002. Pages 488 to 497 incl.

2. Full details are provided in the following QinetiQ reports:
QinetiQ/D&TS/SEA/LR0603209 - MSS6001;
QinetiQ/D&TS/SEA/LR0611732 - MSS6005.

3. Def Stan 07-247 Selection of Materials on the basis of their fire characteristics.