

THE DESIGN, DEVELOPMENT AND PROCUREMENT FOR A NEW GENERATION OF FREE-STANDING NBC AIR FILTRATION UNIT NBC 600

BY

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ABSTRACT

MAES5 is the Design Authority for NBC Filtration and HVAC for the Royal Navy. A programme of development work to improve protection and increase operational efficiency is being progressed. At the same time there is a need to reduce the through life cost. Much of the NBC technology currently in service is old and costly to maintain to the required state in order to provide adequate protection. The development and introduction into service of the NATO radial filter provides real opportunities to redress this situation and develop systems, which will meet all future RN requirements.

The History of Ship NBC Filtration

The need for Collective Protection (COLPRO) was first recognized in 1931, and as a consequence, the then Chemical Defence Experimental Establishment (CDEE) developed and produced what was to be known as the 'PORTON No 1 Chemical Vapour Filter'. Trials were conducted on a light cruiser, HMS *Leander* in August 1932. The unit provided treated air and pressurisation for two of the most important compartments within the vessel namely the telephone exchange and the transmitting station, which housed the electro-mechanical gunnery computer.

The initiative allowed personnel within these compartments to operate free from the constraint of anti-gas respirator and protective clothing (IPE) which was extremely cumbersome since at that time it was also in an early stage of development. The PORTON Vapour Filter, with an associated cooling unit, remained in RN service in this configuration until the late 1950's.

The need for whole ship protection in a toxic environment was first addressed by DG Ships and CDEE in the early 1950's, this work led to the pressurisation of groups of compartments with controlled entry and exit points so as not to compromise the integrity. In order to achieve whole ship pressurisation, priority was given to the development of a new filter unit capable of providing the required pressure and at the same time removing known chemical/biological agents and radioactive fallout. The work began in 1953 and the 'PORTON No 2 filter' was first installed aboard HMS *Cumberland* in 1955.

The Naval Architects at this time were faced with the problems of converting existing platforms to create citadels. This period saw the introduction into service of large numbers of the 'PORTON AFU'; the compact design and small footprint enabled the units to be sited between decks in comparatively small spaces. Subsequently minor modification took place and an improved 'PORTON AFU' was introduced into service during the period 1957 – 1970.

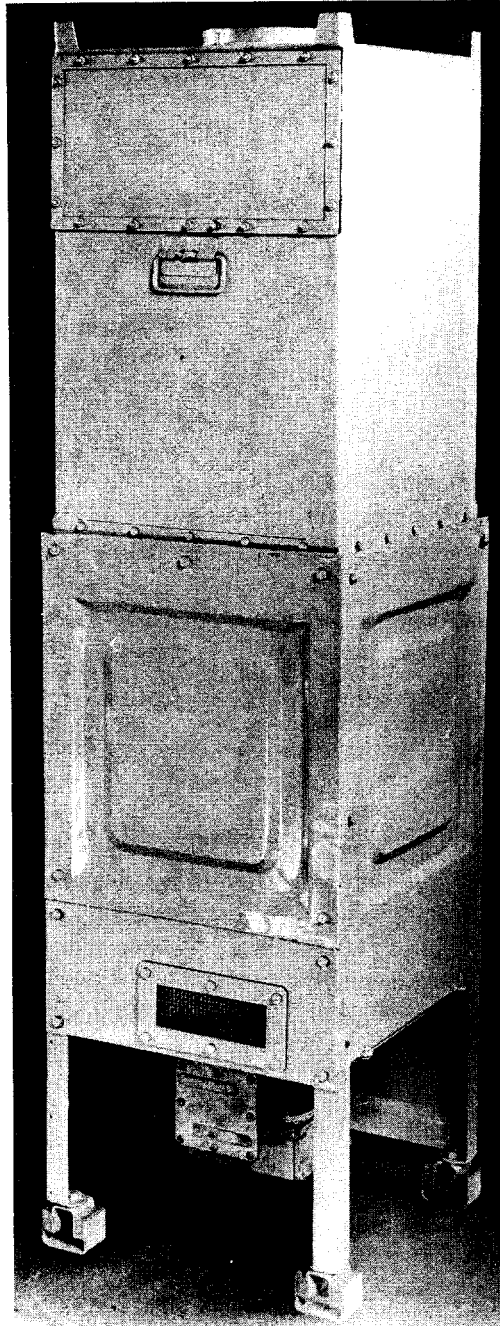


FIG.1 — PORTON AFU

(FIG.1) shows an AFU of circa 1941/42, it can be seen that this unit is very similar to the No 6's and 7 currently in service.

By 1966 the significantly larger No 3 Mk 1 AFU had been developed and introduced into service. The filter system is integrated into the ship's structure and serves an associated Air Treatment Unit (ATU). The air is always drawn into the citadel via the ATU but for some classes of vessel the ATU can be bypassed when NBC protection is not required. HMS *Bristol* was the first ship to receive this fit in 1970, the NBC System with minor modifications such as material changes remain in service to this day.

The Introduction of Radial Filtration to the RN Fleet

In 1991 the Naval Sub Panel of NATO AC 225 Panel VII agreed to the standardization of ship NBC filters to enable full inter-changeability throughout NATO Navies. As the result of this multi-national work, a performance specification (STANAG 4447) was developed for an NBC radial filter and subsequently ratified by member nations in 1994.

MAES5 (then ES235) implemented a programme of work with Industry to develop a filtration system complying with STANAG 4447 and this became known as the NATO Radial Filter Station. The prototype filter station underwent system trials and evaluation at CBD Porton Down. In 1995 a

requirement to provide RFA *Diligence* with additional NBC protection presented the opportunity to convert the prototype filter station for service aboard the vessel. Modifications were undertaken to integrate the ISO container containing the filter station with the ship's structure. The system continues to provide NBC COLPRO for the aft citadel engineering and workshop complex.

Design, development and build of the NBC600

Whilst the above solution provided a NATO radial filter system to replace the No 3 system, a need continued to exist for the development and introduction into service of a replacement for both the ageing No 6 and No 7 AFU's. In 1997 a Statement of Technical Requirements (STR)¹ was written by the author of this article to provide for the design, development and procurement of a free-standing AFU which would utilize the NBC NATO Radial Filter. The STR provided for the direct replacement of both the No 6 ferrous and the No 7 non-magnetic AFU's with a single design. The replacement AFU would be capable of operation at both 50 and 60 Hz thus enabling its use for both the warship application and Ships Taken Up From Trade (STUFT).

Competition for the contract attracted interest from UK and European companies and a contract was subsequently placed during October 1998 with Stork Bronswerk BV of Holland to undertake the design, development and prototype build and test of what was to be designated the 'NBC 600' (FIG.2). The NBC 600 AFU utilises two NATO radial filters with a rated airflow of 300m³/h per filter (600m³/h or 358cfm) per AFU.

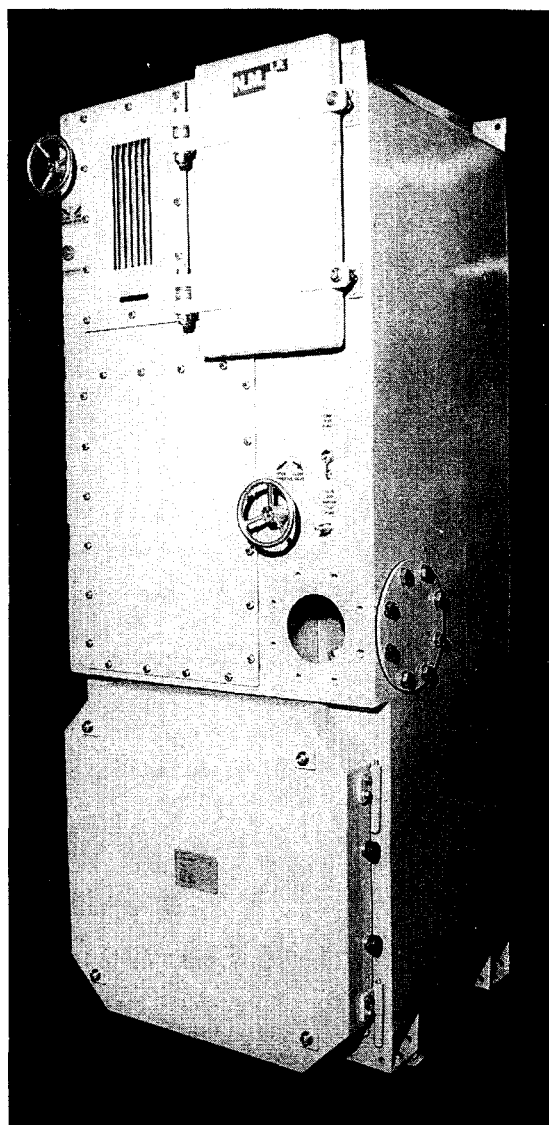


FIG.2 — NBC 600 AFU

In addition to the use of the standard NATO radial filter the opportunity was taken to incorporate many other features that would further enhance the NBC COLPRO fit. Table 1 is a comparison of features relating to both the current No 6 and 7 AFU and the NBC 600. Many of the NBC 600 features are described in more detail later in this article.

¹. — STR ME235/2495

TABLE 1 — Comparison of features

Description of capability	No 6&7	NBC 600
NBC 600 Free-standing AFU B Air delivery 600m ³ /hr.		☆
No6/7 Free-standing AFU B Air delivery 340m ³ /hr.	☆	
Pre-particulate/Particulate/Gas Filtration (I101).	☆	☆
Safe Filter Change' Facility		☆
Quick Change/Load' Facility.		☆
May be sited on an exposed weather deck or within citadel.		☆
Control of influent air relative humidity.		☆
CAMS B Interrogation/test point.		☆
Facility for in-situ challenge of HEPA and vapour filters.	☆	
Blast pressure wave protection valve B (50kPa + 1.5secs static o/p).		☆
Shock protected B NES 1004 and BR3021.		☆
Continual flow rate indication and control.		☆
Facility for remote flow rate indication at Ships Control Room.		☆
Permanent monitoring of differential pressure across each filter.		☆
Overall Size of NBC 600 AFU - 1.85m x 0.75m x 0.75m		☆
Overall Size of No 6/7 AFU - 1.85m x 0.48m x 0.48m.	☆	
Operate 'unloaded' (no radial filters fitted) to serve ATU in normal operational conditions. Pre-filter only is fitted in this mode.		☆
NATO/NBC Filter interchange between member nations.		☆
Fan capable of operation at both 50Hz / 380v and 60Hz / 440v.		☆
Spray eliminator provided (only fitted when sited on weather deck).		☆
Magnetic target acceptable to NES 617 B SRMH & MCMV.	☆(No.7)	☆
Integrated logistic support to DEF STAN 00-60.		☆
Safety Case Assessment to JSP 430.		☆
Reliability, MTBF 6,570 hrs availability, 99.94% over 30 days.		☆
MTTR B 2hrs.		☆
AFU isolation/non return valve.	☆	☆
Unit 25 year life with 52,560 hrs running between major overhauls.		☆

Discussion for the NBC 600 AFU

The value of the contract required an Investment Appraisal (I/A) to be undertaken. The I/A clearly demonstrated that the NBC 600 with a radial filter fit would offer significant through life cost savings whilst improving reliability. It was also recognized that the ability to load/replace the NATO radial filters following a challenge whilst the platform remained in a theatre of operation would significantly improve ship operational availability.

It is expected that the phased introduction and replacement of the existing No 6 & 7 AFU's with the NBC 600 and the introduction of radial filtration on the LPD(R), AO platforms and the possibility of retrofitting the T23 class frigates to replace the No 3 NBC filters will eventually rationalize the number of NBC filters types in RN service. It is considered that the fleetwide introduction of a common NBC radial filter will not only drive down the cost of ownership but will significantly enhance operational availability for NATO member nations.

The NBC 600 has been designed to allow for ease of installation at relatively short notice since the equipment will also provide an NBC protection capability for STUFT. With this capability in mind it is envisaged that war stocks could be

introduced to provide units at short notice for fitting at the time of heightening tension. It is worthy to note that of some 150 STUFT vessels engaged in the Gulf War only four are known to have had any form of NBC COLPRO.²

The NBC 600 may be sited either within the citadel or externally on the weather deck, the location and space considerations will very much depend on whether the fit is at build or in a retrofit situation. Filter changes may be achieved without risk of contamination when sited within the citadel since a 'safe change' system has been developed and integrated into the AFU design. Filter exchange can be achieved in the closed down situation without the need for localized isolation/decontamination, which is not the case in respect of the No 6 and 7 AFU's.

The complete NBC 600 system provides for quick and easy ship fitting and is particularly suited to a 'fit to receive situation'. The unit has been physically sized to allow for shipping and installation within a vessel without having to cut the structure as the overall size enables it to pass through standard watertight doors and hatches.

Mode of Operation

A single unit or a bank of units can be monitored at their respective control panels or alternatively by a central remote facility. The control panel is provided with a 16 functional key pad, the software for both the monitor menu and alarm system can be accessed by the operator/maintainer through the key pad which is protected by an access security code.

The menu provides the operator/maintainer with the status of the AFU and will display the current running mode of the AFU. The NBC 600 can be operated in either the NBC (operational) or Dummy (simulation) mode.

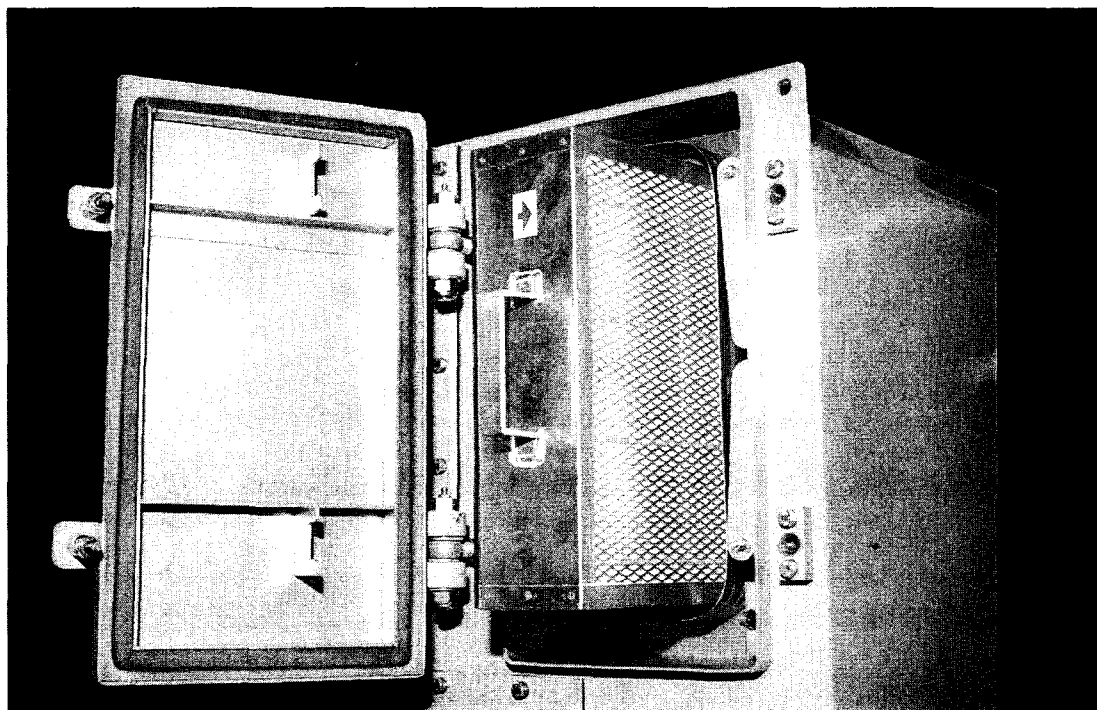


FIG 3 — PRE-PARTICULATE FILTER HOUSING — FILTER PARTIALLY REMOVED

In the NBC mode the unit will be operated with the Pre-particulate and NBC filters fitted (Figs 3 & 4), the valves are fully open providing full protection to

2. — Source of information CBD Sector Porton Down

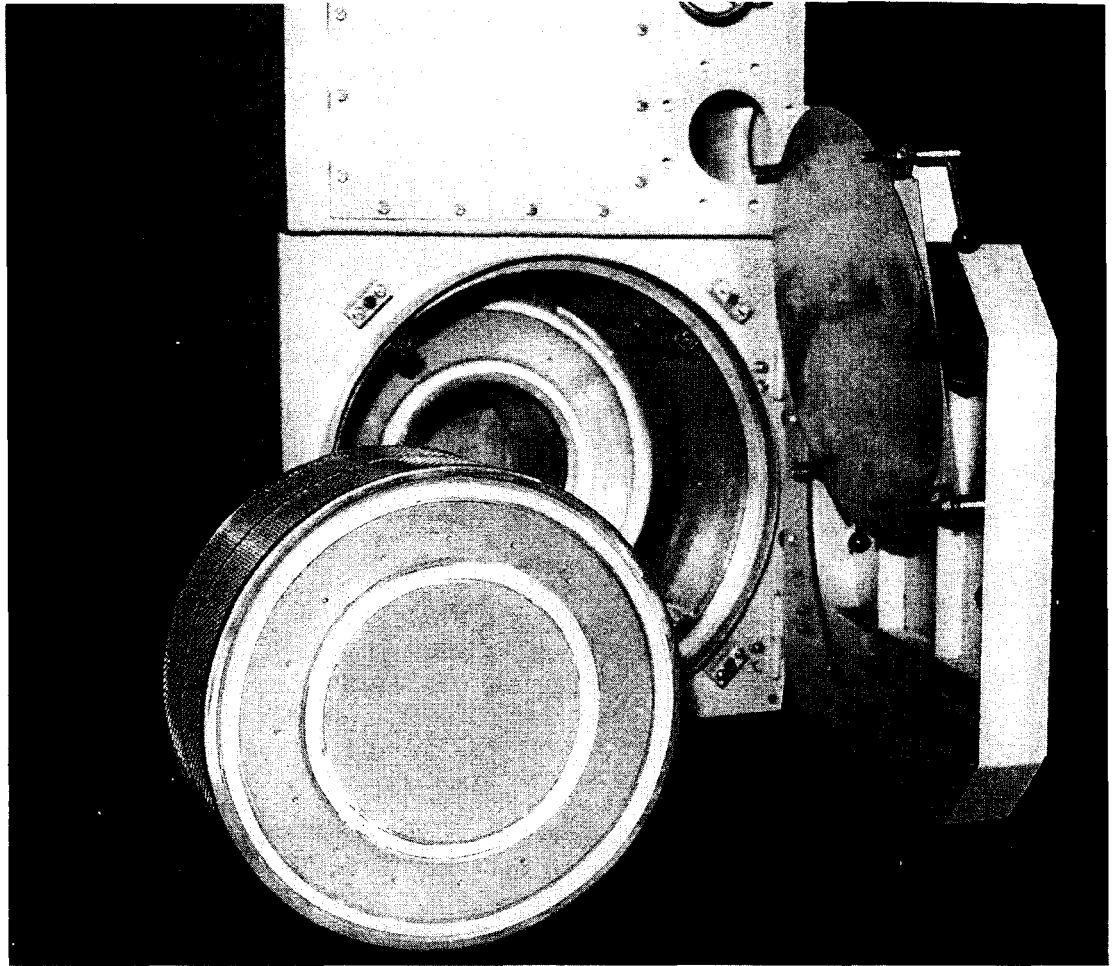


FIG.4 — RADIAL FILTER CHAMBER COMPRESSION PLATE REMOVED WITH ONE OF TWO NBC RADIAL FILTERS LOADED

the citadel. For use in the Dummy mode only the pre-particulate filter will be fitted in order to provide clean air to the citadel. This mode will serve the ship in normal operation and may be used to simulate a closed down situation for training purposes. In this mode the intake valve is set to restricted to compensate for the reduction in differential pressure since the NBC filters are not loaded.

Control and Management

The alarm menu will display all alarms fitted to the AFU. In the event that an alarm is activated, the occurrence will be displayed and a red LED will illuminate in the appropriate reset function key. The alarm message generated by the PLC will be displayed and can be both acknowledged and reset.

There are two levels of alarm which may be activated, they are:

Essential alarms

When activated will automatically close the AFU down until the problem is rectified and the alarm reset on the keypad. The display will, for example, identify and report any breach of the system such as a door partially open. In such a situation the function key with the appropriate LED will illuminate to identify the location of the offending door. The AFU will not run until rectification action is complete and the function key acknowledged by the maintainer.

Advice alarms

May be acknowledged and reset on the keypad so that the AFU continues to run. The advice alarm will reactivate 24 hours later if the required maintenance task has not been carried out and the key acknowledged. This alarm level serves to ensure that the operator/maintainer activities are addressed to provide optimum protection and efficiency of the system. Whilst a maintenance alarm will not close down the AFU, the appropriate alarm will continue to reactivate until the rectification task is complete and the keypad acknowledged by the maintainer.

Conditioning of Influent Air

The operator display will also indicate the level of preheat for the influent air which can range from 0% to 100%. Alternatively it may be set to automatic mode in which case the influent air will be monitored and heated in stepped increments to ensure the air is treated sufficiently to prevent premature degradation of the NBC filter charcoal beds.

Other functions displayed are:

- Position of intake valve — open/closed/restricted (dummy mode).
- Position of throttle valve — open/closed.
- Air temperature — supply/delivered (°C).
- Pre-particulate filter differential pressure (Pa).
- NBC radial filter differential pressure (Pa).
- Airflow (M³/hr).
- Total running time of AFU (hr)

Summary

The NATO Radial Filter Free-standing unit has been designed to replace both the No 6 and 7 AFU's currently in service and will meet fully the requirements for both the SRMH and MCMV.

Full NATO codification has been undertaken and supporting documentation is available. Installation and interface drawings have been produced and are available for the development of A&A guidance.

Future fitting opportunities include the new RFA *Argus* hospital facility. The AFU has been specifically designed with the upgrading of the existing SRMH COLPRO system in mind.

In anticipation of forecast demands a production run of twenty five AFU's will become available for ship installation as of August 2000. MAES5 have purchase options in place for further batches of AFU's to meet forecast demands.

The possibility of providing war reserves for installation at the time of heightening tension to RFA and STUFT platforms to meet operational requirements will be considered.

Acknowledgement

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