EUROPEAN FUSION DEVELOPMENT AGREEMENT
JET

EFDA–JET–CP(02)05/18

P.D. Brennan, A.C. Bell, K. Brown, C. Cole, B. Cooper, C. Gibbons, M. Harris, G. Jones, S. Knipe, J. Lewis, C. Manning, A. Miller, A. Perevezentsev, N. Skinner, R. Stagg, M. Stead, R. Thomas, J. Yorkshades and JET–EFDA contributors

Maintenance of the JET Active Gas Handling System

Maintenance of the JET Active Gas Handling System

P.D. Brennan, A.C. Bell, K. Brown, C. Cole, B. Cooper, C. Gibbons, M. Harris,
G. Jones, S. Knipe, J. Lewis, C. Manning, A. Miller, A. Perevezentsev,
N. Skinner, R. Stagg, M. Stead, R. Thomas, J. Yorkshades
and JET–EFDA contributors *

Euratom/UKAEA Fusion Assoc., Culham Science Centre, Abingdon, Oxon, OX14 3DB, UK
[*] *See annex of J. Pamela et al, 'Overview of Recent JET Results and Future Perspectives', Fusion Energy 2000 (Proc. 18th Int. Conf. Sorrento, 2000), IAEA, Vienna (2001).*

Preprint of Paper to be submitted for publication in
Proceedings of SOFT 2002 (Helsinki, Finland, 9–13 September 2002)

INTRODUCTION

The JET Active Gas Handling System (AGHS) has been in operation in conjunction with the JET machine since Spring 1997. The tritium levels within the vessel have remained sufficiently high, 6.2g at the end of the DTE1 experiment and currently 1.5g, such that the AGHS has been required to operate continu ously to detritiate gases liberated during D-D operations and to maintain discharges to the environment to ALARP. Maintaining the system to ensure continued operation has been a key factor in guaranteeing the continued availability of the essential sub-systems. The operational history of the JET AGHS has been previously documented in a number of papers[1,2,3]. Operational downtime is minimised through well-engineered sub-systems that use high integrity components. Outage, contamination and operator dosage are minimised through pre-planned and prepared maintenance operations. The reliability of sub-system critical condition fault detection is demonstrated through routine testing of hard-wired alarms and interlocks.

1. OPERATIONS PHILOSOPHY

The constant service provided by AGHS to the machine at JET relies on maintenance, which has the following essential features:

1) Safety interlocks
2) Routine plant monitoring
3) AGHS Plant maintenance
4) Maintenance of plant services

1.1. SAFETY INTERLOCKS

The safety case of the AGHS makes some basic assumptions for the failure frequency of the various hard-wired interlocks that operate when the plant approaches critical conditions. The operation of these interlocks is routinely tested on a six monthly basis.

These tests take the form of physical simulation of the process event that cause the interlock to activate. It is normal for the trip to shutdown of the cause of the fault condition. Heaters are set to exceed their normal operating temperatures, testing power shutdown at the trip point. Inactive gases, such as argon or nitrogen, are substituted when testing pressure switches, pressurising the volume until the trip pressure is reached. For ion chambers an external gamma source is used to provide sufficient ionisation as to trigger the interlock etc. It should be noted that for thoroughness a practice has been developed of always raising the physical process parameter to exceed the instrument trip level rather than setting a physical process parameter and lowering the instrument trip level until the interlock is triggered.

1.2. ROUTINE PLANT MONITORING

The AGHS is continually monitored either by AGHS staff or remotely by JET main control room staff who have the support of an on-call AGHS Operations Engineer. The outgoing AGHS duty

Operations Engineer will request the monitoring of process parameters and identify priority hardwired alarms requiring investigation, should they occur. Formal daily checks are routinely carried out and sub-systems inspected, recording state of key parameters, in accordance with written procedures. A duty Operations Engineer is always available to respond to, and investigate, any fault that occurs.

Plant operating experience has provided a knowledge of failure symptoms. This permits corrective action to be pre-planned, allowing an optimum response to failure, or preventative maintenance carried before failure occurs. The Exhaust Detritiation System (EDS) is required to operate continuously and items such as blowers and valves have failed in the past. Experience has shown that the blowers bearing vibration amplitude increases a short time before failure. When this is noted work is planned for the relevant EDS dryer rack to be taken out of service and the blower bearings replaced. Similarly certain valves on the EDS show signs of imminent failure by indicating an undefined state on the EDS mimic when opened or closed.

1.3. AGHS PLANT MAINTENANCE

Very little preventative maintenance is carried out on the AGHS plant so that downtime and tritium exposure is minimised. Operations therefore rely on holding essential spares with the capability of responding quickly to breakdowns. This often necessitates having procedures in place and radiological and working risks assessed. Some sub-systems have redundancy, which allows maintenance to be carried out without shutting down the sub-system. However, maintenance plans will also consider contingencies when this is not the case. The AGHS undertakes breakdown maintenance as a pre-planned operation .

Removal of Normetex pumps from the Mechanical Forevacuum Casemate

The last day of campaign C4 saw the introduction of Silane into the machine. Special precautions therefore had to be taken when the machine cryopumps were being regenerated. The gas liberated during regeneration was diluted with nitrogen to ensure that this was below the lower explosive limit. Further complications appeared at this time due to a water leak on NIB 4. This mixture was mechanically pumped to EDS with an additional nitrogen purge. A fault occurred on the 600m^3/hr Normetex pump shortly after the mechanical pumping. An investigation demonstrated that the pump had seized in a manner similar to that seen previously on other Normetex pumps.

The main AGHS activity during the 2001 autumn shutdown was to remove failed pumps, one 600m^3/hr and two 150m^3/hr, from the MF Casemate. The casemate is a sealed room that acts as secondary containment for the pumps and associated pipework. The MF Casemate being tritium contaminated, which after clean up was at an average level of 100Bq/cm^2, further complicated this work. The inlet and outlet pipework of each pump was purged with dry air. Bubbler measurements taken to determine the levels of tritium contamination before the pipework was breached and flanges blanked. Bubbler samples, taken during initial purging, recorded tritium concentrations as high as 4.8GBq/m^3. These levels were reduced to 72MBq/m^3 through a combination of trace heating and air purging. The results of these measurements were referred to when deciding on appropriate level of radiological protection equipment, specified in consultation with Health Physics. Pipework breaches were carried out using locally ventilated isolators. The pumps were then wrapped in plastic sheeting to prevent the spread of tritium contamination. The next step was to remove them from the Casemate and, as the room was built around the pumps, it was necessary to dismantle the front wall. When this was completed, the pumps were moved to a storage location in the AGHS main process area using a combination of jacks/skids and an overhead crane. Contamination was contained and the operation was carried out with minimal dose to operators. Pump failure is thought to be due to corrosion caused by exposure to water liberated during machine bake-out and from NIB water leaks. It is planned to dismantle the pumps in the near future in order to ascertain the precise failure mechanism. Alternative pumps, to replace the failed Normetex pumps, were identified prior to the shutdown. These were Leybold 605 Duradry pumps, that were modified (alternative oil and metal seals), in order to make them compatible with AGHS operational requirements. These pumps were delivered late to Culham on 9 October 2001, consequently reducing time available for installation and commissioning. During site acceptance tests, one of the pumps exhibited a fault that required replacement components to be shipped from the supplier. A decision was then made to install the new pumps in series configuration in order to achieve the machine pump-down program. New interface cubicles for electrical and control installation were also required to be fabricated and installed as the original Normetex units had been supplied with their own dedicated control system. The most serious problem that arose during this part of the installation was the lack of detailed control interface drawings from Leybold. This was eventually resolved through direct contact with Leybold design personnel in America. The pumps were commissioned in time for pump-down on the 26 November 2001. The pumping configuration may be changed in the future to improve the pumping speed of the MF system.

1.4. MAINTENANCE OF PLANT SERVICES

The operation of AGHS relies on certain key services to be operational round the clock. These include power, instrument air, chilled water and ventilation. EDS is the only AGHS sub-system that requires to be operated continually. Services required for EDS, being power, chilled water and instrument air also become critical plant and as such detection of failure of these are immediate and indicated on the hardwired interlock panel. Statutory inspection, regular filters changes and replacement of worn components during planned maintenance inspections generally ensures that plant is maintained to a high standard and as such breakdown and down time is kept to a minimum. There is also redundancy built into the systems EDS has two power feeds from different 11kV transformers. The chilled water system, which supplies EDS coolers, comprises a duty and standby unit, again with diverse electrical feeds. Compressed air is supplied from two of three units that operate alternately, switching automatically, to ensure shared duty. This allows routine or breakdown maintenance without effecting supply.

2. MAINTENANCE PARAMETERS

In addition to carrying out work, all maintenance undertaken by the AGHS has essential key elements:

1) Planning & Preparation
2) Contamination Control & Operator Dose
3) Commissioning & Set-to-work

2.1. PLANNING & PREPARATION

Maintenance, is like any other work carried out by the AGHS, in that it requires careful planning which includes providing a written procedure and risk assessments under the umbrella of a safe system of work. In addition to this it is often necessary to set up a radiological controlled area. This planning and preparation of maintenance work, was recently put to the test (January 2002) when the EDS inlet filter became almost completely blocked
within a very short period. The sequence of events that followed were:

- simple, planned tests carried out to confirm that the filter was blocked;
- emergency planning meeting held with the Authority to Operate holder, responsible officer and available AGHS engineers to plan and allocate appropriate actions;
- take appropriate temporary action, in this case it was decided to open the by-pass line and restrict AHGS operations to prevent ingress of material;
- writing work procedures, undertaking COSHH, risk assessment;
- manufacture tents, isolators, mechanical aids and stool;
- prepare the replacement 19 candle filter elements;
- setting up an ion chamber sampler at the EDS inlet, using this information to access activity and potential operator dose levels, undertaking a radiological risk assessment;
- set-up the working area, tent and monitoring equipment.

2.2. CONTAMINATION CONTROL & OPERATOR DOSE

A radiological risk assessment, using best practicable means, is always carried out prior to work being undertaken. In the case of the EDS filter change this was derived from a previous study of off-gassing from stored graphite flakes, from the JET machine, and results of an ion chamber test was taken at the inlet of the filter.

The assessment determined a pessimistic off-gassing rate of 300GBq/h with a possible airborne exposure of 90MBq/m^3 (300 DAC). The levels of radiological protection were then advised by JET's resident health physics section, in this case undertaking the work in pressurised suits, in addition to using isolators and a fully sealed tent.

The work in removing the filter housing was carried out with little airborne activity, with the highest recorded levels being approximately 1 kBq/m^3. The low levels of contamination and activity was attributed to effective containment at every breach. Isolators were positioned as illustrated, Figures 1 & 2, and the filter was removed in the following manner:

- Remove the spool piece above the filter housing;
- Break the bottom flange;
- Jack the upper pipework and withdraw the filter housing;
- Exchange the filter in an isolator, sealing the old filter in the isolator;
- Reinstall the housing;
- Carry out leak test and set-to-work.

The potential for the highest activity release was in the replacement of the filter in its housing. It was demonstrated that this work could be carried out on contaminated items while maintaining satisfactory containment. Smears taken during the work were analysed and the level of contamination for the filter top was shown to be 34 kBq/cm^2.

The internals of the isolator was demonstrated to have a surface contamination of 2.28 kBq/cm^2. An important feature, at this stage, which contributed to satisfactory containment, was the bagging technique used to contain the old filter element during dismantling. This is illustrated in Fig. 2, where the isolator becomes the sealed bag after it is triple welded and cut to leave three separate, sealed, components. The maximum airborne activity of this stage was 2.98 kBq/m^3.

2.3. COMMISSIONING & SET-TO-WORK

It is a JET quality assurance (QA) requirement to demonstrate that the performance, and suitability for tritium containment, of any system that undergoes modification is as its original design and specification. However, with operating plant, it is not always possible to carry out the original test in order to demonstrate this. In this case a leak test of the installation, to demonstrate that the leak rate was in the range 0-10 x 10^{-7} mbar litre/s, could not be carried out. After consultation with QA section, a test was carried out after installation, where the filter housing was filled with 0.5 barg of helium, then a Quick Test probe on the ultratest leak detector was used to ‘sniff’ all the newly assembled joints for leakage. This test confirmed that the leak tightness was better than 10 x 10^{-7} mbar litres/s.

CONCLUSION.

The AGHS maintenance regime has ensured that it has remained available to support the machine operations at JET. Work on critical items, such as the EDS inlet filter and mechanical for vacuum pumps, illustrate the value of planning and good preparation in minimising the spread of contamination and operator dose levels during maintenance operations. Safety in all operations, whether scheduled or an emergency response is a culture adopted by AGHS. This has a long-term benefit for health and safety, overall plant operations and the ability of the AGHS to perform its supporting role to machine operations.

ACKNOWLEDGEMENT
This work has been carried out under the European Fusion Development Agreement.

REFERENCES
[1]. R. Lässer et al, "Commissioning Tests and Enhancements to the JET Active Gas Handling Plant*", Proc. of the 19th SOFT Conference.,* Vol. 1, p. 227-232, Lisbon, Portugal (1996).
[2]. R. Lässer et al, "Operation of the JET Active Gas Handling System During and After DTE1*",* *Fusion Engineering and Design*, **46**, p. 307-312 (1999).
[3]. P.D. Brennan et al, "Operation of the JET Active Gas Handling System in Support of Machine Operations 1998-1999", *18th Symposium on Fusion Engineering*, Albuqueque (1999).

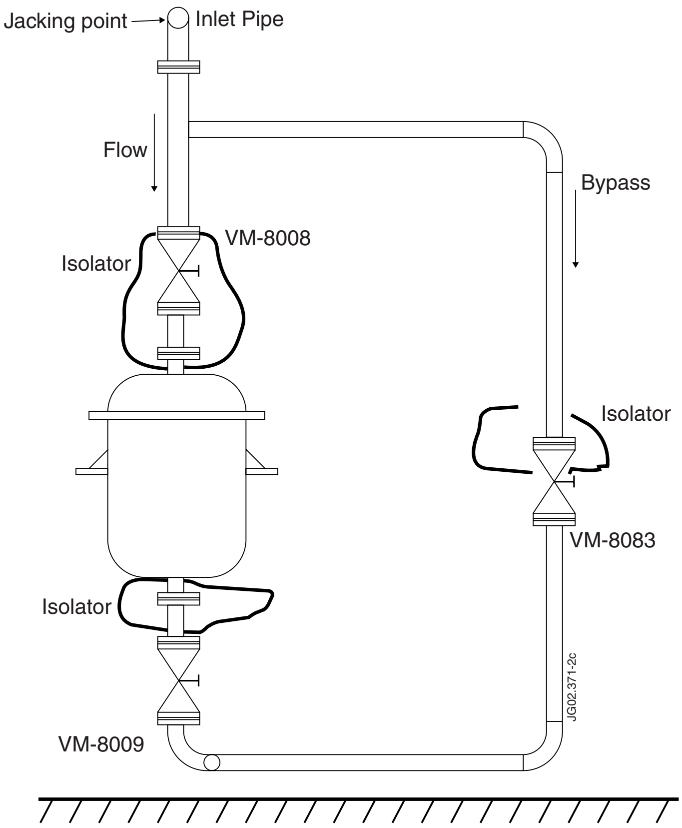

Figure 1: Isolator Locations for EDS Filter Housing Disconnection.

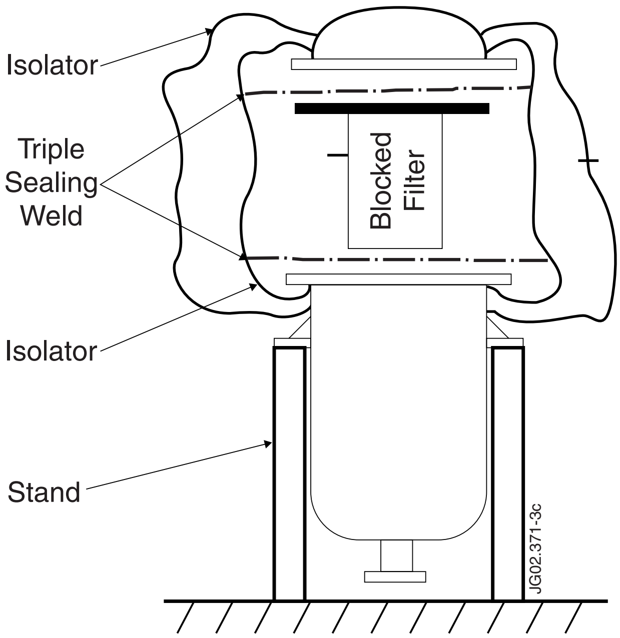

Figure 2: Positioning of Isolators for Filter Replacement.