JOINT EUROPEAN TORUS

JET–P(87)24

T. Budd, C.J. Caldwell-Nichols, B. Green and M. Marshall

Computerised Radiation Protection in the Working Environment at JET

Computerised Radiation Protection in the Working Environment at JET

T. Budd[1], C.J. Caldwell-Nichols[1], B. Green[1] and M. Marshall[2]

JET-Joint Undertaking, Culham Science Centre, OX14 3DB, Abingdon, UK

[1]*JET-Joint Undertaking, Culham Science Centre, OX14 3DB, Abingdon, UK*
[2]*Environmental and Medical Sciences Division. AERE Harwell, Oxon, OX11 0RA, UK*

Preprint of Paper to be presented at an IAEA Seminar on
The Application of Computer Technology to Radiation Protecction
Bled, Yugoslavia, 22nd June - 26th June 1987

IAEA-SR 136/41.

COMPUTERISED RADIATION PROTECTION IN THE WORKING ENVIRONMENT AT JET.

T. BUDD, C.J. CALDWELL-NICHOLS, B. GREEN and M. MARSHALL.

ABSTRACT

This paper considers the use of computers in the radiological protection systems on the Joint European Torus (JET) experiment at Abingdon in the UK. JET is the largest fusion experiment in Europe. It uses a sophisticated computerised control system and the radiological protection systems are integrated into the overall control structure. The main protection systems are a radiation monitoring system for the JET buildings and an access control system. The access control system includes a facility for recording the radiation doses incurred on each visit to a controlled area.

1 INTRODUCTION.

The Joint European Torus (JET) is the largest Tokamak in Europe and forms the largest fusion research program of the European Atomic Energy Community (EURATOM). Its main objective is to study plasmas in conditions approaching those required for a fusion reactor. The machine operates in a pulse mode producing pulses of hot plasma for up to 20 seconds every 10 to 20 minutes. The best results obtained so far are within about a factor of 25 of the product of plasma density, temperature and confinement time required for self-sustaining fusion reactions. Current experiments utilise hydrogen and deuterium plasmas. From 1990 experiments are planned with plasmas of deuterium and tritium and significant fusion reactions will then be expected. The current status of the project is described in references [1] and [2].

Radiological protection systems are essential to the safe operation of the JET device. At present photo-neutrons and hard X-rays are produced during operation and this has caused some activation of the JET vacuum vessel. There are also small numbers of neutrons from deuterium deuterium fusion reactions. When tritium operation starts there will be much higher levels of fusion neutrons from deuterium tritium reactions and there will also be a need to monitor for tritium around the Torus and the tritium recycling plant.

Systems at present installed monitor radiation levels in the JET buildings and control entry of personnel to areas where radiological hazards may exist. These systems are connected to a computer and are integrated into the total JET Control and Data Acquisition System (CODAS). This paper starts with a brief review of the JET control system. It then describes in some detail the radiation protection systems in use at JET. Particular emphasis is given to the use of the computer system to provide convenient control and display facilities.

2 THE JET CONTROL AND DATA ACQUISITION SYSTEM (CODAS).

The overall control and monitoring of the JET machine is done through a network of mini-computers. The control is arranged in a hierarchical manner as shown in figure 1. Overall control of machine operation is carried out using the machine console computer (MC). This sends commands (via a communication hub computer) to a network of approximately 20 on-line subsystem computers. Each subsystem computer controls several local units. These local units may be controllers for plant, diagnostics for experiments, or safety systems. After a pulse, data is assembled from each subsystem in a single JET Pulse File and is then sent to a main frame computer for storage and subsequent analysis. The control system is described in more detail in reference [3].

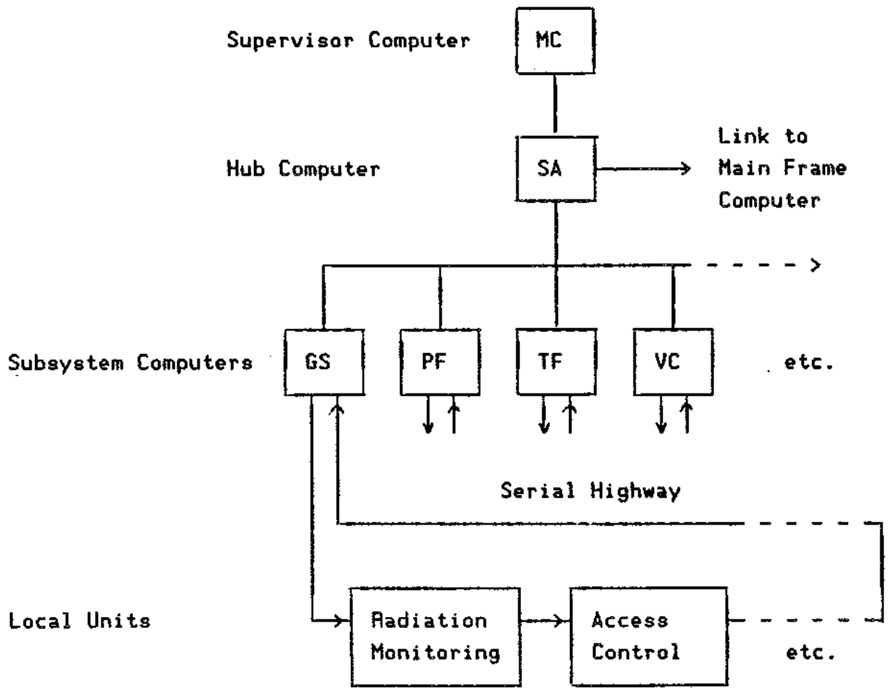

Figure 1. Simplified Diagram of JET Computer Control System.

The radiological protection systems are integrated into this control structure and utilise standard JET hardware and software as far as possible. At present they run on the General Services subsystem computer (GS) along with many other local units. It is planned to move these systems on to a separate computer in the near future as they have special requirements for high availability.

The computers used at JET are Norsk Data 100 and 500 series machines. These are interfaced to the plant using Computer Automated Measurement and Control (CAMAC) equipment [4]. Each computer has a number of CAMAC crates connected to it via a fibre optic highway which multiplexes all the necessary control signals. The GS computer has 14 such crates handling 2000 signals. One of these crates contains the necessary interface modules for the radiological protection systems.

The main operator interface is from a series of consoles in the machine control room. Each subsystem computer has its own console consisting of at least one display screen and a touch panel screen. The GS console has additional screens for closed circuit TV and for monitoring the personnel access control system.

3 JET AREA RADIATION MONITORING SYSTEM.

3.1 Overview of System.

Radiation detection monitors are placed at various locations around the JET buildings. They are used to record both radiation levels during machine pulses and background levels in the JET buildings between pulses. There are now 30 installed gamma-ray monitors and 12 installed neutron monitors. Each monitor gives an output in the form of a train of pulses proportional in rate to the radiation field at the monitor. These pulses are counted by CAMAC scalers.

Software running on the General Services (GS) computer reads the CAMAC scalers and calculates dose information. This information is always available for display on the GS system console in the machine control room. It is also archived in a data base for further analysis. If an unexpectedly high level of radiation is detected an alarm is raised on the JET centralised alarm system. During operations these alarms are continuously monitored by an operator.

3.2 Hardware.

The radiation detectors used at JET are listed in table I. High level radiation detector heads are placed in the torus hall (which houses the tokamak itself). These detectors are ion chambers which produce a low current proportional to the radiation field. They are joined to their associated electronics by a super-screened cable so that the electronics can be located in a lower radiation field outside the torus hall. The electronics digitise the current from the head to give a TTL pulse output. These pulses are led into adjacent 16 channel, 32 bit CAMAC scalers. The high level monitors are designed to have an adjustable sensitivity. At a later stage in the project the sensitivity may be changed to give a range of 3 μSv to 300 mSv per pulse or even higher.

Medium level radiation monitors are placed elsewhere in the JET buildings in areas where people may be working during machine operations. They produce a simple pulse output of rate proportional to the radiation field. They are installed at distances of up to several hundred metres from the scalers and use optical fibres to avoid electrical interference on long cable runs. Optical receivers then convert the signals to TTL pulses which are led into the CAMAC scalers.

Table I. Area Radiation Detectors used at JET.

Detector	Description	Dose Range µSv/Pulse	Comments
High Level Gamma HLG (For Torus Hall)	Ion Chamber IG32 20th Century Electronics.	0.03-3000	Range can be changed. Includes check source.
High Level Neutron HLN (For Torus Hall)	BF3 Ion Chamber with Moderator Assembly. AERE type 0071.	0.03-3000	Range can be changed. Needs Gamma correction. Includes check source.
Medium Level Gamma MLG (For Other Areas)	Energy Compensated Geiger. AERE type 0740.	0-10	Also records background radiation.
Medium Level Neutron MLN (For Other Areas)	BF3 Proportional Counter. AERE type 1940A.	0-6	No Gamma correction required.

3.3 Software.

The Software for the radiation monitors consists of 3 dedicated real time programs and 2 terminal-orientated background programs. In addition standard in-house software is used for data display and alarm handling. The system stores information in a local data base. This was also developed in-house. The data is stored in direct access files which are accessed by record number or through a single key. A hashing algorithm is used for the keyed access files to derive a home position for the record. This paper descibes only the dedicated programs written specially for the radiation monitoring system. Some information on the general control software used at JET is given in reference [3].

The radiation monitoring programs are as follows:

1) Real-time data accumulation program (OLA).
2) Real-time dose calculation program (OLM).
3) Real-time archiving program (OLH).
4) Display and report generation program (OLP).
5) Data base management program (OLC).

The data accumulation program (OLA) is responsible for reading the CAMAC scalers containing the counts from the radiation monitors. It runs continuously and outside of machine pulses it takes background readings every 5 minutes. It also responds to messages from the system software supervising a pulse and takes additional readings before and after a pulse to measure pulse doses. This program runs at a high priority to ensure that readings are taken with the minimum of delay.

After each reading doses are calculated by OLM. This program gets information on the calibrations for each monitor from the data base. It corrects doses for internal reader backgrounds and it corrects the neutron readings for the gamma-ray sensitivity of the monitors. (This is done by first calculating the gamma-ray or X-ray dose from an adjacent gamma monitor). The doses are then stored in either a background dose file or a pulse dose file as appropriate.

A summary of the dose data is produced by OLH. This program runs once an hour to calculate the mean dose within that hour. It also calculates mean background doses and total pulse doses for daily, monthly and yearly periods. All this information is stored in the radiation monitoring data base for later analysis. Thus it should be possible to detect gradual changes in radiation levels.

Data from the data base can be displayed and printed by OLP. This program is run from a terminal when required. An example of a report of pulse doses from 4 torus hall monitors is shown in table II. Information on monitors is kept up to date by a data base management program, OLC. This is also run from a terminal when required.

Table II. Doses recorded from a typical pulsing session (in μSv).

Date	Time	Pulse	Gamma Monitors HLG2	HLG4	Neutron Monitors HLN2	HLN4
01/10/86	15:48	10169 P	33.51	18.48	1320.95	1201.96
01/10/86	16:35	10170 P	35.76	19.74	1392.81	1279.96
01/10/86	17:13	10171 P	37.73	20.90	1440.15	1333.59
01/10/86	17:52	10172 P	28.19	15.71	1157.47	1045.63
01/10/86	18:22	10173 P	22.27	12.38	930.67	832.50
01/10/86	19:09	10174 P	30.84	17.12	1226.46	1121.30
01/10/86	19:36	10175 P	23.23	12.93	987.33	881.27
01/10/86	19:57	10176 P	40.09	22.30	1502.28	1404.75
01/10/86	20:39	10177 P	451.22	83.04	1198.98	1144.41
01/10/86	21:14	10178 P	0.00	0.04	0.01	-0.01
01/10/86	21:35	10179 P	25.16	12.05	805.86	736.36

3.4 Console Displays.

The main interface to the radiation monitoring system is through the GS system console in the control room. A number of displays are provided to show the positions of monitors and the current dose details. Background radiation level, last pulse dose and total pulse dose that day are shown for each monitor. An additional panel on the display shows any alarms on the system. An example of one of the displays is shown in figure 2. This includes a diagram of the torus hall with the 4 walls folded flat to show the position and height of the monitors. The radiation monitoring system displays are selected as required from the touch panel screen on the console.

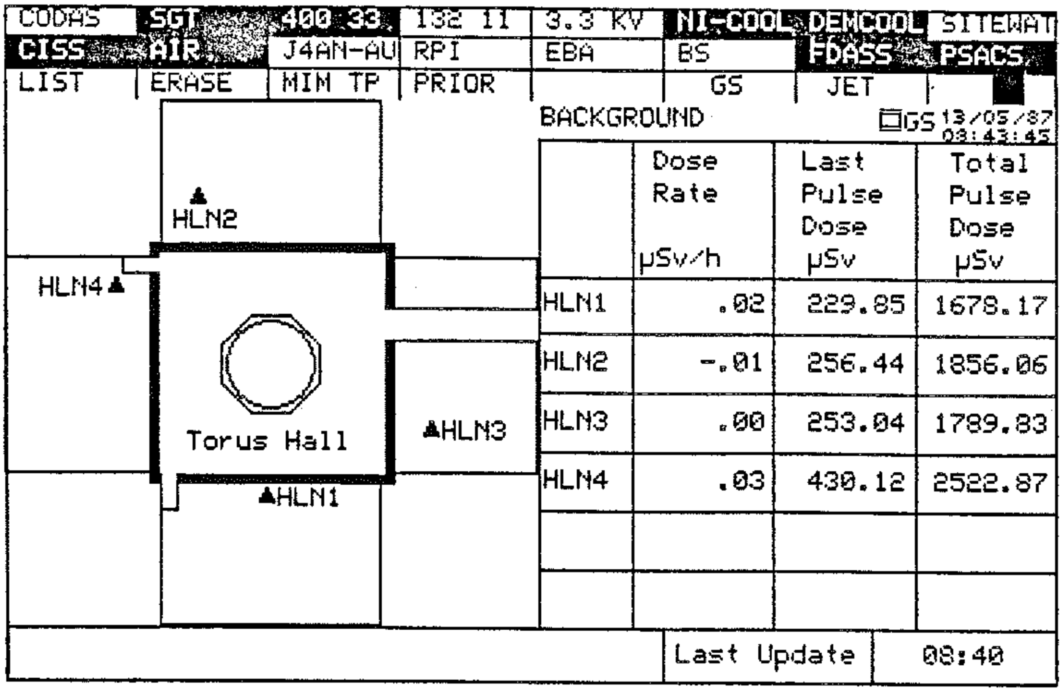

Figure 2. Example of Display of Radiation Monitoring Data from Torus Hall Neutron Monitors.

4 JET PERSONNEL SAFETY AND ACCESS CONTROL SYSTEM. (PSACS)

4.1 Overview of System.

There are several areas in the JET buildings where no access is allowed when the machine is operating and where access needs to be controlled and personnel dosimetry provided at other times.

In these controlled areas basic safety is ensured by a hard-wired key interlock system. This system ensures that the doors can only be unlocked when all machine systems are in a safe state. This interlock system is supplemented by hard wired emergency push buttons which shut down the machine. Personnel Dosimetry is provided primarily by a Thermoluminescent Dosimetry (TLD) system described in reference [5]. As a backup a computerised access control and visit dosimetry system is also installed. This system includes an electronic pocket dosimetry system which can record individual doses each time a visit to a controlled area is made.

As this paper is concerned with the use of computers this section is confined to the access control system. This system has five access control barriers with combined pass and dosemeter readers. The readers are connected to the General Services computer using a CAMAC interface module on the serial highway. The computer checks all requests for entry and, if necessary, asks for confirmation from a shift technician in the machine control room. If a pocket dosemeter is required it is zeroed on entry, and read out on exit from the area. These dosemeters also provide a continuous visual read out and an alarm facility. All entries to controlled areas are logged by the computer and details of doses received are processed by JET personnel dosimetry service programs [5].

4.2 Hardware.

The hardware for the access control system is based on a dosimetry system supplied by Alnor of Finland. Pass card readers identify people to the system. Dosemeter readers check and zero dosemeters on entry and read out any doses received on exit. The readers are connected to the GS computer by a CAMAC interface module in a crate connected to the standard CAMAC serial highway. An RS232 protocol is used for the link to the reader.

The passes used by the system are integrated with standard site passes in use at JET. A copper strip is embedded in the pass with a BCD identification number represented by holes punched through it. The dosemeters used by the system are Alnor RAD80S dosemeters. They are battery operated Geiger-Muller counters and provide a permanent display of accumulated dose equivalent from 0.001 mSv to 999.9 mSv. The dosemeters also gives a bleep for every 2.5 nSv received and have a high dose audible alarm setable on entry by the computer.

At each access control point there is also a turnstile barrier For an entry, the turnstile is unlocked by the computer (and no access is possible when the computer is not working). For an exit, the turnstile is unlocked by the reader to allow exit in the event of computer failure. The dosimetry information is then held in the reader and transferred to the computer when communication is re-established. The readers also have battery backup to maximise the probability of successful exit from an area.

4.3 Software.

The software for the access control system consists of 2 dedicated real time programs and 1 terminal orientated utility program. As with the radiation monitoring system information required for the access control system is stored in a local data base.

The data base 'Master Access File' contains the following information:

For each person on the system:

1) Name.
2) Pass card number.
3) Access right (given separately for each controlled area).
   Rights may be Automatic, Manual or No access.
4) Dosemeter Required or not (given separately for each controlled area).

For each controlled area:

1) Name of area and details of barriers.
2) Overall access right for area.
   Rights may be Automatic, Manual, Normal or No access.
   All area access rights except Normal override individual access rights.

The access control programs are as follows:

1) Real-time Barrier Access Control Program (BRACP).
2) Real-time Barrier Access Support System (BRASS).
3) Data Base Management and System Utility Program (BR-UTIL).

The access control program (BRACP) controls all entries and exits to the controlled areas. When a user attempts to use the system to enter an area the program checks the access rights set for the person and the area. If No access is allowed the user is notified and no further action taken. If Automatic access is set the user is let straight in. If Manual access is set a special display comes up on the subsystem computer console in the machine control room requesting that the access be allowed or denied. The operator must then use the touch panel screen to allow or deny access. When the access is made the date and time are stored in the computer. When the person leaves the controlled area the date and time are again stored along with any dose received by the person. This information is written to a simple sequential 'Access Record File' which is transferred once a day to the personnel dosimetry service.

The access support program (BRASS) is responsible for maintaining a special display of the state of the system on the GS subsystem console. The displays are considered in the next section. The data base management program (BR-UTIL) is used to add information on users and controlled areas to the data base. it can also be used to print reports on the personnel using the system and to display at a terminal some information on the state of the system.

4.4 Console Displays.

As with the radiation monitoring system, the main interface with the user is through the GS system console in the control room. There is a small screen reserved for the access control system. This usually shows details of the last entry to or exit from a controlled area. An example of this display is shown in figure 3. The touch panel on the console can also be used to request a display of the names of people in a controlled area (figure 4) and to request a display of the state of the system.

As well as operating the access control system, the GS computer monitors the status of the hard wired components of the PSACS system. This information may be displayed on the main screen of the computer console. An example of one of these displays is shown in figure 5. This shows a map of the ground floor of the JET buildings along with the status of emergency push buttons, doors and other penetrations in the biological shield. A cursor control may be used to select other displays from the short list at the bottom right of the display.

```
ACCESS CONTROL

Incomplete Accesses:    7

Exit Complete           Card: 09592
Martin A
Vacuum Vessel.
29-04-87 11:03:42  Alarm: 100µSv
Dosimeter: 30126   Dose:    1µSv


The ARF is now ONLINE
```

Figure 3. Access Control System: Display of last Action.

```
ACCESS CONTROL          IN AREA  5

Card: 09120  Johnson T
Card: 09409  Hookham C
Card: 09526  Limpenny R
Card: 09548  Hatto P
Card: 09552  Williams J
Card: 09638  Ireson R
Card: 09639  Milton H
```

Figure 4. Access Control System: List of current entries to controlled area.

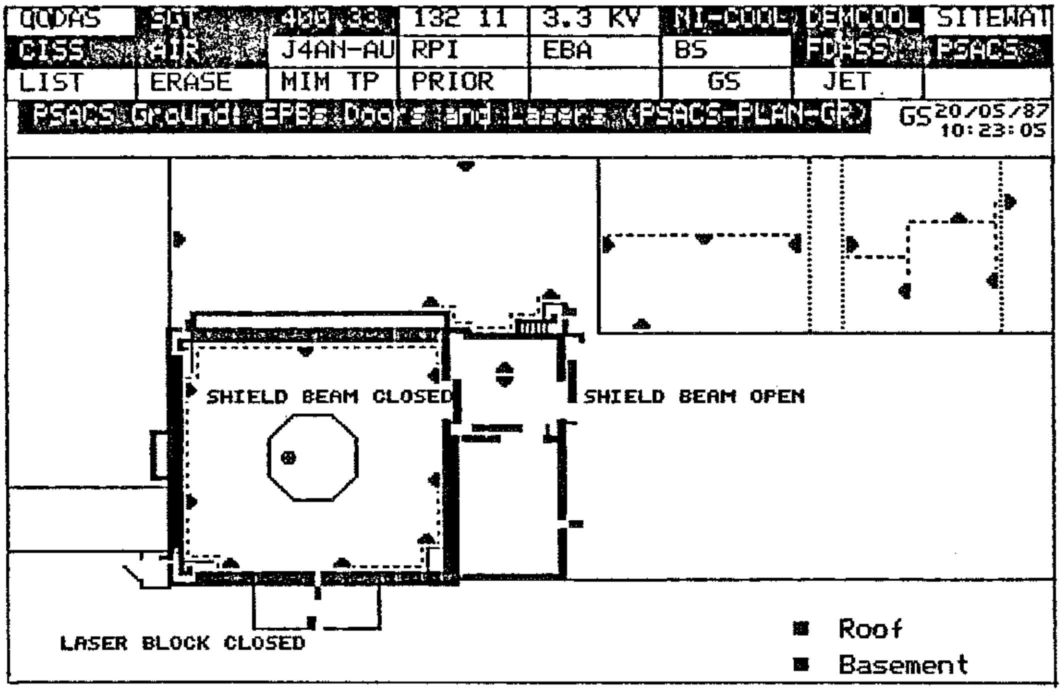

Figure 5. Display of door and push button status.

5 CONCLUSIONS.

The JET experiment relies on a sophisticated computer control system to pulse the machine, store experimental data and monitor all auxilliary equipment. The radiological protection systems are integrated into the overall control systems to provide flexible and convenient control and monitoring. The major systems monitor radiation levels and control access of personnel to areas of potential hazard. These systems have now operated very successfully for 4 years. To date the levels of radiation in the JET buildings are low, but when tritium is used at a later stage in the experiment, neutron doses could rise to several Sievert per pulse in the torus hall. The radiological protection systems will then become essentual for the safety of personnel working on JET.

ACKNOWLEDGEMENT

The Authors wish to thank M. Tilley of System Designers PLC. for writing the Access Control software programs.

REFERENCES.

[1]: Rebut P.H., et al., "JET Latest results and future prospects", 11th Int. Conf. on Plasma Physics and Controlled Nuclear Fusion. Kyoto Japan, (1986).

[2]: Rebut P.H. and Keen B.E., "JET, Present status and prospects", Fusion Technology 11 1 (1987) 13.

[3]: van der Beken H., et al., "The JET control and data acquisition system, Fusion Technology 11 1 (1987) 120.

[4]: "CAMAC: a modular instrumentation system for data handling." EAEA rep. EUR-4100 (1980).

[5]: Baker D.M. and Budd T., "The Joint European Torus personnel dosimetry service", Seminar on the Application of Computer technology to Radiation Protection. IAEA-SR-136, Bled, (1987).