1.1

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24 August 1989

Dear Sir/Madam

HOT LABS CONFERENCE
27 AND 28 SEPTEMBER 1989
AT KARLSRUHE

Please find attached my paper, Number 1.1 on the Agenda, for the above Conference.

Yours sincerely

D H CARTER
Building Manager, A59

ACTIVE HANDLING EXPERIENCE AT WINFRITH

25 YEARS OF OPERATIONAL EXPERIENCE IN THE ACTIVE HANDLING AND DECONTAMINATION BUILDING, A59 AT WINFRITH, DORSET, ENGLAND

D H Carter

1 *HISTORICAL*

The United Kingdom Atomic Energy Authority opened a new Research Establishment at Winfrith Heath in the County of Dorset in Southern England in 1957.

One of the first buildings to be erected was the Active Handling and Decontamination Building, A59. The design was based on a similar building (459) at Harwell. Its purpose was to carry out the Post Irradiation Examination of fuel elements and components from a variety of Reactors and supply a decontamination service to the building and the site as a whole. In its early years a plan view of the building was as shown in Figure 1.

The main features of this were:-

1 Two lines of beta/gamma concrete caves, the North Cave Line (NCL) Caves 1 to 5 and the South Cave Line (SCL) Caves 8A, B, C. Each cave has internal dimensions of 2.6 m wide by 3.65 m deep and 4.3 m high, the walls are 1.52 m thick. Each cave had an operating station on one face with a Zinc Bromide window and two master slave manipulators (MSM). There were intercave shut off doors between most modules.

2 A Storage Area serviced by a 40 tonne crane and housing floor storage holes.

3 A Cave Access Area between the cave lines.

4 External cave extract HEPA filters of a 0.6 m x 0.6 m x 0.3 m rectangular design, protected by an attached spark arrestor. These primary filters were backed up by charcoal Iodine traps and banks of secondary HEPA filters.

5 A Decontamination Bay

6 A Workshop

7 A Pressurised Suit Area (PSA) for operations involving alpha activity

8 Vehicle and Flask Washdown Area

Caves 4 and 5 were set up for the Post Irradiation Examination (PIE) of fuel elements from the Dragon High Temperature Reactor based at Winfrith. This work commenced in 1966.

Cave 3 ran a series of campaigns on CANDU and Windscale Advanced Gas Cooled Reactor (WAGR) fuel element examination.

Caves 1 and 2 were set up for active metallography in conjunction with the adjacent lead cell.

The early years of operation confirmed the basic design philosophy of the building.

The start up of the 100 MW(e) Steam Generating Heavy Water Reactor (SGHWR) in 1967 provided additional work. Initial problems with crud induced failures of the SGHWR fuel element cladding resulted in extensive PIE being carried out in the SCL during 1968 until the cause of failure was established. Routine PIE of SGHWR fuel has continued ever since.

In the early 1970's the UK Central Electricity Generating Board (CEGB) entered into a 10 year contract with the Authority to utilise the NCL for Commercial Advanced Gas Cooled (CAGR) fuel element and component PIE. As a result of this the Dragon PIE was moved to the SCL and the NCL was extended by building a receipt and despatch cave (Cave 7) and a storage cave (Cave 6) (Figure 2).

The most significant modification performed was the installation of five new operating stations fitted to the South face of the NCL using a unique "building block" design (Figure 3) which gives the building operator great flexibility of choice. An additional crane of 30 Tonne capacity was installed in the storage area so that the 56 Tonne CAGR Flask could be handled by the 30 and 40 Tonne cranes working in tandem. A small general purpose cave (Cave 9) was built on the site of the vehicle washdown bay which had never been used.

The years from 1972 to 1977 were used by the CEGB to examine water reactor fuel in the NCL from both SGHWR and several Overseas based Reactors.

The closure of the Dragon Project came just before the first delivery of CAGR fuel in 1977 and so the SGHWR PIE was moved back to the SCL leaving the NCL exclusively for CAGR examination. This situation prevails today, although in 1986 the CEGB requested the use of the SCL for 8 months of each year for the next 6 years. The SCL was refurbished in six months to accommodate this request and additional operating stations were installed, again using the building block technique, in the SCL North face. Figure 4 shows the current ground floor plan view.

An intercave transfer system was also installed to enable active material, up to 1 metre long by 240 mm diameter, to be transferred between the NCL and SCL. The transfer system consists of a purpose built shielded transfer flask and gamma-gates built into the cave walls adjacent to an operating Station in the NCL and SCL. The insertion of these gamma-gates was simple and cost effective because of the building block construction of the two operating stations concerned.

The joint CAGR and SGHWR PIE campaigns in the SCL have run smoothly since 1983. Currently the NCL and SCL are handling some 120 CAGR fuel elements and components per year in addition to 1 or 2 SGHWR fuel elements and the occasional SGHWR pressure tube. Other water reactor fuels are periodically examined as requested.

Cave 9 is predominantly used for non-fissile waste sorting and packing in addition to non-fissile CAGR and SGHWR component examination.

The Decontamination Bay has been and still is being highly utilised by both the building, the SGHW Reactor and other customers.

2 *EQUIPMENT: THE LESSONS LEARNT*

2.1 Originally each cave line was fitted with a Power Manipulator and a 3 Tonne capacity crane. In the case of the Dragon PIE operations much of the fuel element handling was based on the use of the power manipulator. This proved to be a mistake since when it broke down most, if not all, of the PIE work stopped until it was repaired. An important lesson learnt is that dependence on a single, complex, in-cave item can cause major programme throughput problems when it breaks down.

Once the NCL and then the SCL had the additional operating stations fitted the power manipulators were removed from the lines. The 3 Tonne cranes were also found to be too cumbersome for many uses and were replaced by 500 kgm cranes, 3 in the NCL and 2 in the SCL all of uniform design. These are used with purpose designed sequencing grapples to give the operator greater flexibility and ease of handling.

2.2 A valuable lesson in cave equipment design was fortuitously learnt when the CAGR fuel deliveries were delayed. Originally very large, complex, multi-purpose machines had been installed in the NCL for CAGR element examination, metrology and dismantling. These were inactively commissioned and then removed from the cave line to await delivery of CAGR fuel.

In the meantime small, technique-specific, machines were built for the SGHWR and other water fuel PIE. These were fastened to tracking laid on the cave benching. The more manageable small machines could be moved into position and locked onto the track, used, and then replaced by other machines. This gives greater flexibility to the operator and multi use of an operating station. This technique was so successful that when the CAGR fuel arrived, the PIE was carried out using similar, more versatile, machines. This has an added advantage in that should a big complex machine fail, all work stops until it is repaired. With the small machines it is possible in many cases to have two, one in operation and one as a spare.

2.3 In some cases it is necessary to have fairly large machines. In this case we have learnt that design with repair and disposal in mind is vital. Units likely to fail, such as motors, rams and transducers, must be remotely detachable with spare units available.

Large steel framed equipment and storage racks should be made from bolted together sections so that they can be dismantled for ease of eventual disposal.

3 *OPERATIONAL PROBLEMS WITH 25 YEAR OLD PLANT*

3.1 None of the items discussed below are causing any significant Radiological or Operational problems. However it is interesting to speculate what changes would be made if designing a replacement facility against today's standards.

In many areas attempts have been and are being made to rectify early design anomolies.

3.2 Ventilation

3.1.1 There are three ventilation systems in the building.

(i) Main Building Ventilation
(ii) NCL, SCL, PSA and storage hole ventilation
(iii) Cave 9 and decontamination bay ventilation

Systems (ii) and (iii) are known as the "Hazard Extract".

The original building ventilation was not very efficient, particularly in heating the building in winter, and was completely replaced six years ago.

The main caves, PSA and storage hole extract was originally achieved by two fans. Cave 9 and the decontamination bay are extracted by a single fan. A third, high capacity, extract fan has been fitted as an additional safety feature. This can be used to maintain the necessary depressions in all the hazard extract systems should either of the original fans fail.

3.2.2 Originally the only ventilation plant instrumentation were liquid manometers on the cave faces indicating cave depression. These were never particularly successful. Instrumentation which indicates flow rates into and out of the main building was installed along with the new main building ventilation system. Mechanical devices known as "flow grids" have been placed in the cave extract ducts to measure and display cave extract flow and pressure drop.

3.2.3 In spite of the shortcomings; there has been no radiological evidence that the original cave and decontamination bay extract systems have worked anything other than safely and reliably for 25 years.

3.3 Filters

3.3.1 The original concept of putting the primary cave HEPA filters, with their associated spark arrestors, external to the caves now seems extraordinary. It had been anticipated that operations between the major cave lines, in the so called Access Area, would be carried out in pressurised suits. This was never instituted and with the addition of the extra operating faces the filters are now situated below an operational area. Some of the filters have to be changed on a radiation level criteria rather than pressure drop. The radiation levels have to be sufficiently low, typically 6 to 10 mSv gamma on contact, so that they can be changed with minimum operator dose and disposed of as low level waste. The changes are performed outside normal working hours to avoid interruption to work programmes.

3.3.2 We are currently looking at the possibility of changing to circular filters for more cost effective waste disposal, as these can be volume reduced more readily in the circular waste drums.

3.4 Iodine Traps

The original iodine traps were rectangular containers of activated charcoal with a perforated lid. The charcoal was held down by copper gauze. Not only were these not very effective, but over extended periods the charcoal was sucked out and deposited on the secondary filter bank. We have changed to honeycomb type iodine traps and hold these in stock for installation when fuel with less than 100 day cooling is received for examination.

3.5 Shielding

3.5.1 Master Slave Manipulators (MSM)

The building has worked for many years with NEL Mk 9 manipulators at the operating stations. These have proved to be extremely reliable. With good equipment design, operator training and MSM maintenance the average life between breakdowns of an installed manipulator is 12 months.

Because the Mk 9 manipulator requires additional shielding and withdrawal onto the operating face for repair on breakdown, they are progressively being replaced by the VNE 80 manipulator which is fully shielded and has a detachable slave arm.

3.5.2 South Cave Line East Transfer Chamber

When the SCL became one large cave, the opening of the Eastern door to allow posting in or out of large equipment caused a gamma shine to be emitted into the building. Additional shielding has been erected to minimise the effects of this, but man access to part of the building has to be restricted when the cave end door is opened. A scheme for fully shielding the SCL East transfer chamber is being drawn up.

3.6 Flask Posting Operations

The majority of posting operations are carried out through ports in the cave walls or roofs. None of these ports has a sealed posting device. Consequently, in spite of rigorous cleaning of the external surfaces of containers, the ports and flask bores do become contaminated. Carefully controlled posting operations ensure that this causes no radiological problems. Retrospective fitting of sealed posting systems, although feasible, is both difficult and costly.

3.7 Decontamination Bay Operations

The decontamination methods employed are very much "hands-on" techniques using water, steam lances and acid baths. By thorough staff training and the use of tongs and local shielding, the initial high levels of contamination (up to 50 mSv gamma on some items) can be removed without undue exposure of the operators. Modern methods of decontamination are being developed at Winfrith and these will be installed into the decontamination bay as they are proved effective for routine use.

4 PERSONNEL EXPOSURE STATISTICS

In spite of these inevitable criticisms of a 25 year old plant, a study of the personnel whole body dose exposure makes interesting analysis and demonstrates how the average exposure has been significantly reduced over the years against a background of greatly increased throughput.

Figure 5 shows the average industrial personnel (cave operator) exposure over a 9 year period from 1969. It can be seen that in the early days the average was high at about 45 mSv (4.5 R). This had been reduced by a factor of about 2.8 by 1977. Figure 6 shows the average personnel exposure from 1978 to 1988 and Figure 7 gives a breakdown of the data. Figure 8 shows the distribution of whole body dose by working categories of personnel for the past six years. Local perturbations against the general downward trend of average dose in 1984 and 1987 can be accounted for by the fact that there were significantly more man entries into the caves for refurbishment in those years.

This reduction in average dose has been achieved by:-

(i) Studying working practices against dose received and adjusting operating procedures and techniques to minimise dose uptake.

(ii) Ensuring that the general background within the building is kept as low as possible.

(iii) Thorough training of personnel in both operating procedures and radiological awareness.

It is essential, particularly in old active handling plant, that there is very close co-operation between the building management and the Health Physics organisation.

5 *CONCLUSIONS AND RECOMMENDATIONS*

5.1 It has been demonstrated that 25 year old Active Handling Plant can be operated safely and cost effectively at high throughput. To achieve this, considerable thought must be given to the planning, equipment design and radiological aspects of the work programmes.

5.2 Caves constructed by modular design give a great degree of flexibility of operation. They also enable major changes to programmes to be encompassed and aid ease of eventual decommissioning.

5.3 Caves Lines with operating stations on both sides give a greater degree of flexibility, more effective use of in-cave space and can decrease the need for large powered manipulators.

5.4 Operations should not be centred around large complex machines. Thoughtful equipment design is paramount. Units likely to fail must be removable. If large framed structures are necessary they should be constructed in modular form from bolt together sections. These aid maintenance and repair, thus reducing down time. It also aids eventual disposal.

5.5 If possible machines should be bought to the operating station and locked onto tracking for use. This increases the use and flexibility of an operating station.

5.6 Primary filters should be easily and cleanly changeable. The "push through" design concept aids this requirement.

5.7 Concise Operating Instructions and structured operator training are essential for achieving programme targets with minimum radiological hazard.

6 Further information can be obtained from:-

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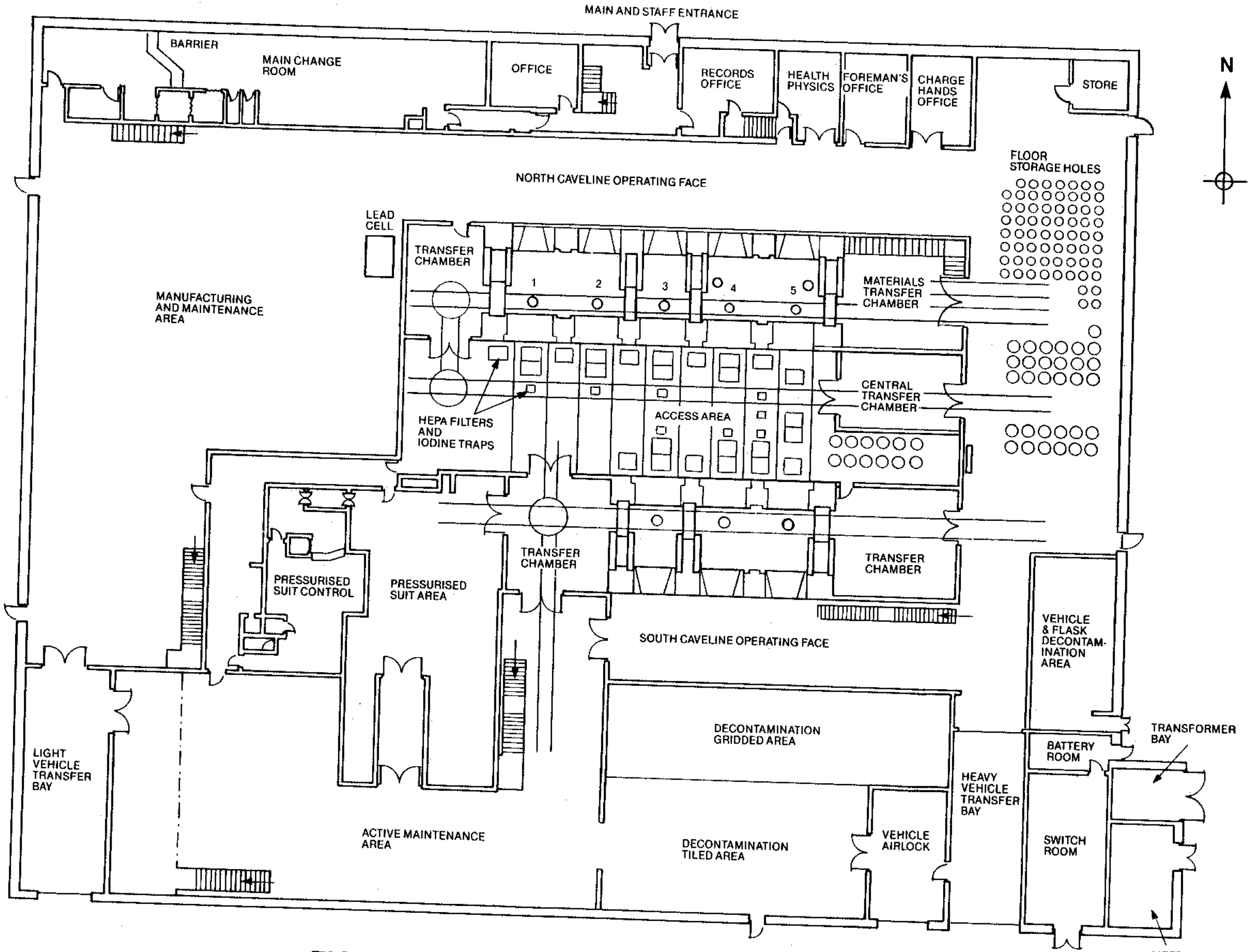

FIG. 1 A59 ORIGINAL GROUND FLOOR PLAN

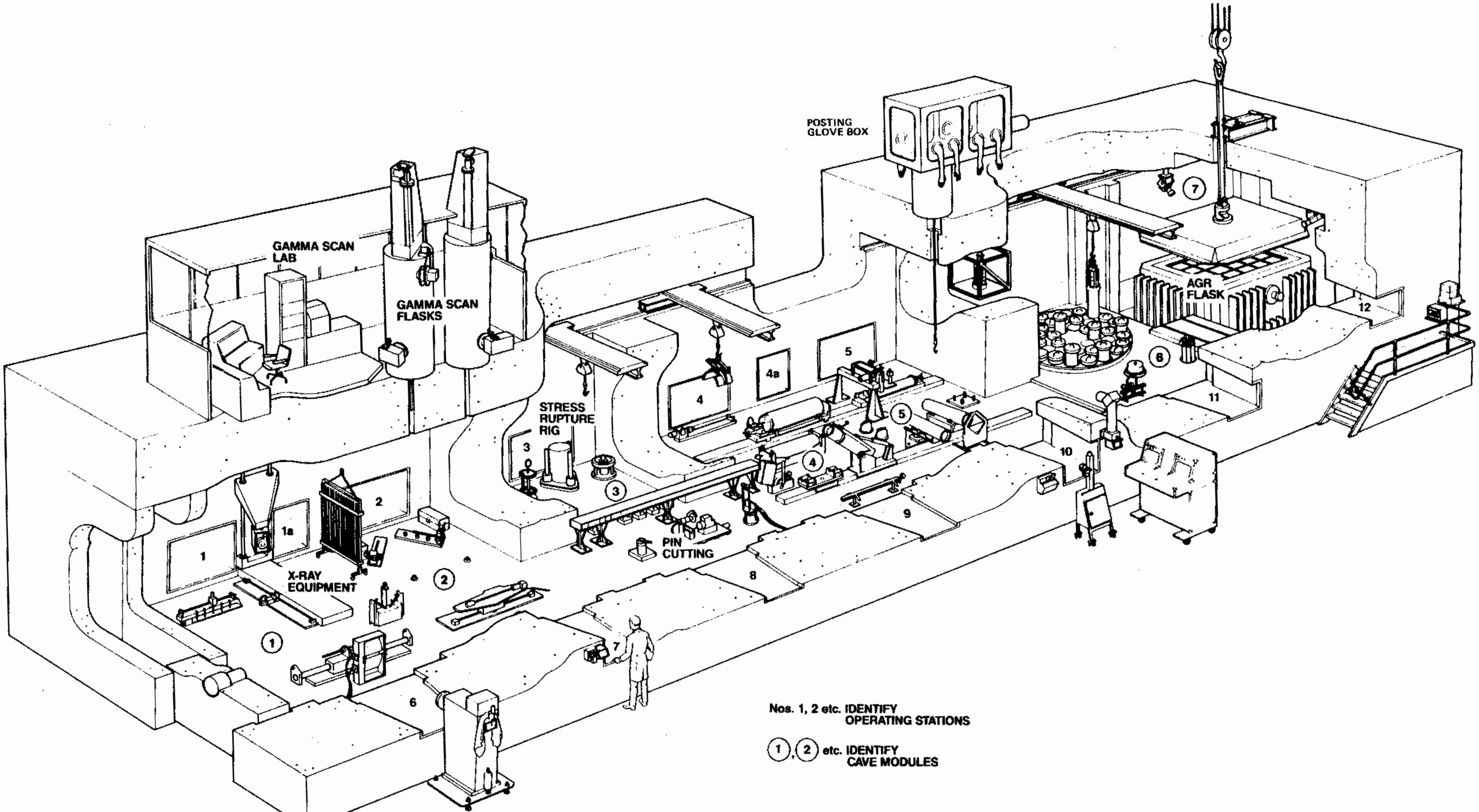

FIG. 2 CUTAWAY VIEW OF A59 NORTH CAVE LINE FROM SOUTH WEST

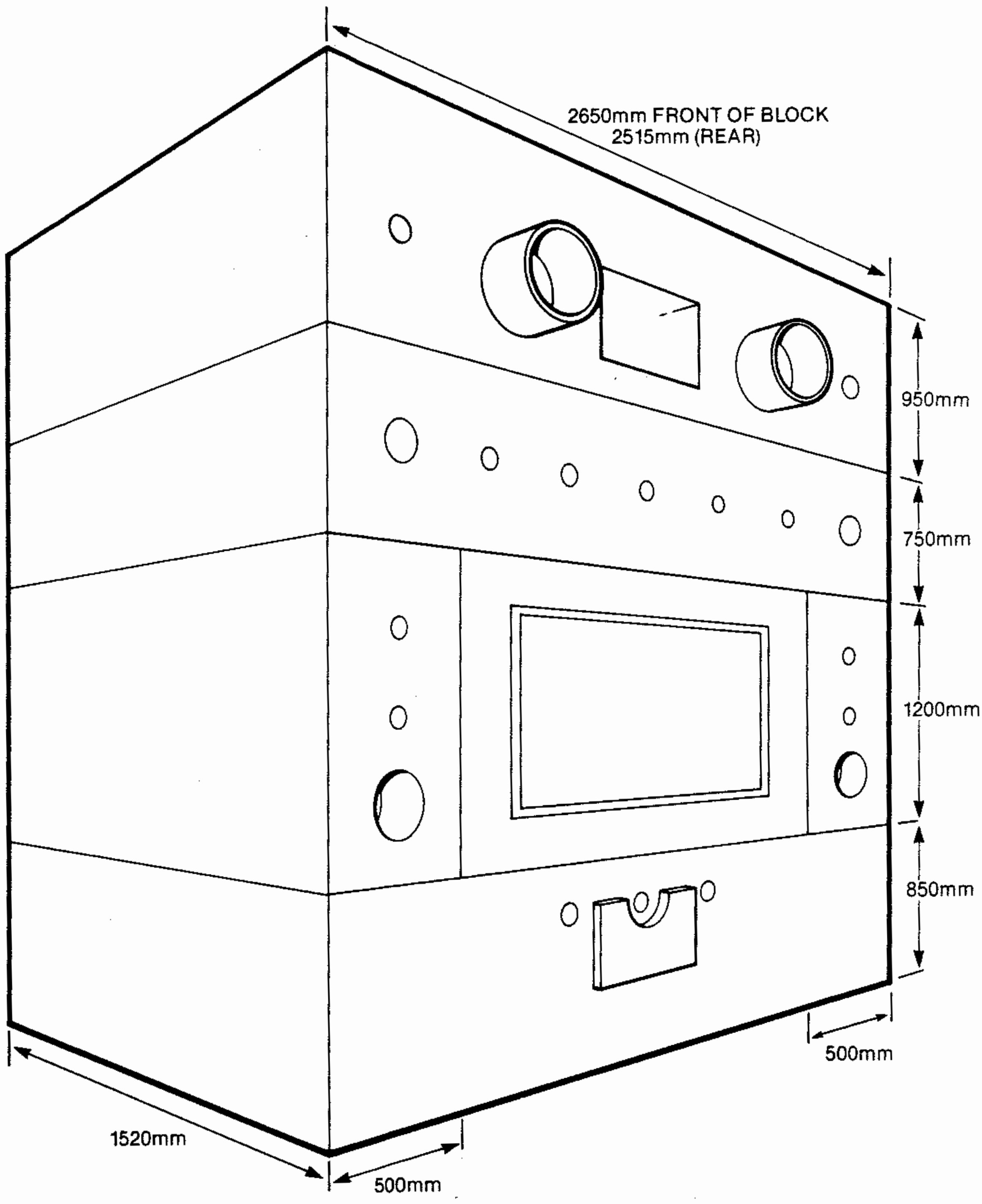

FIG. 3 OPERATING STATION SHOWING MODULAR CONSTRUCTION

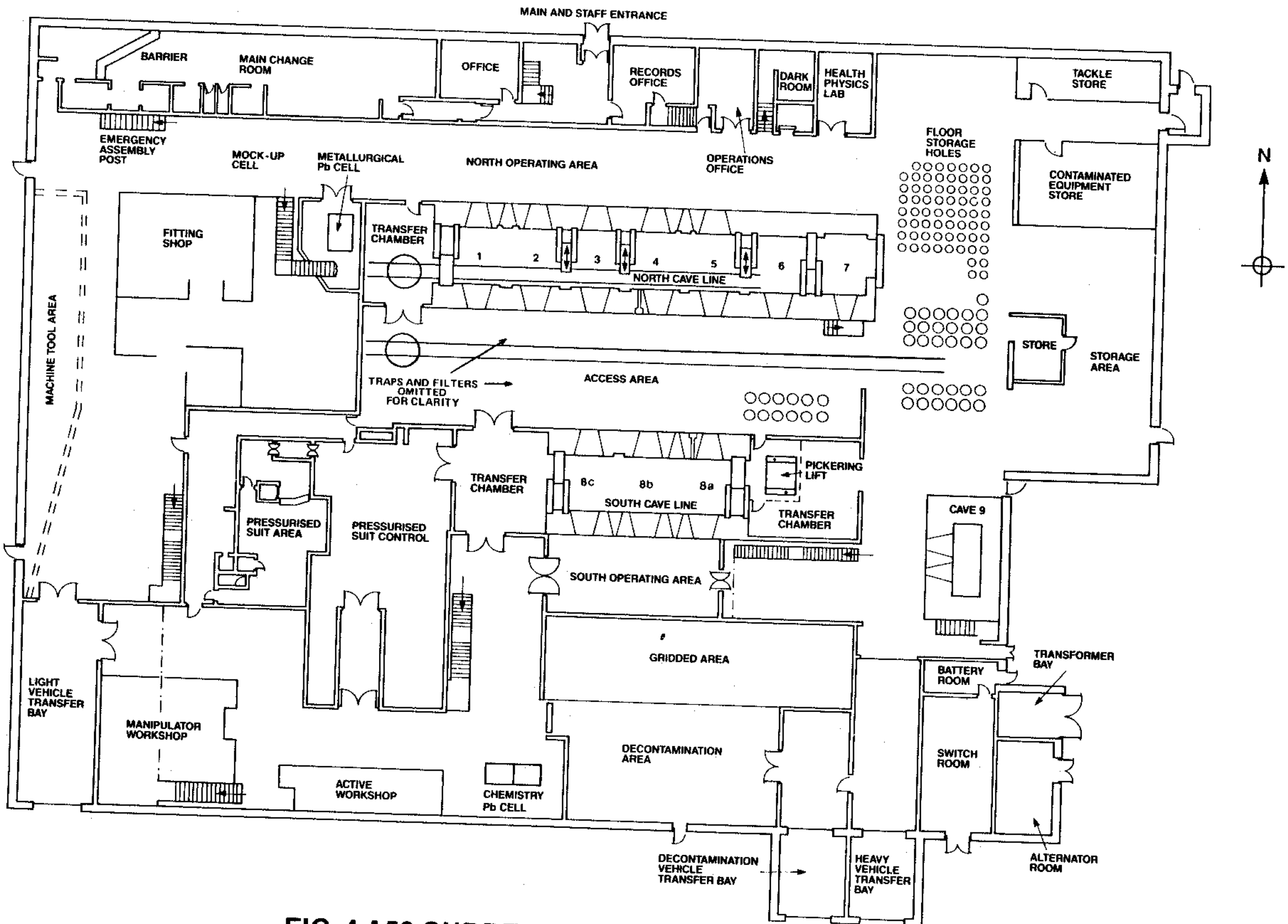

FIG. 4 A59 CURRENT GROUND FLOOR PLAN

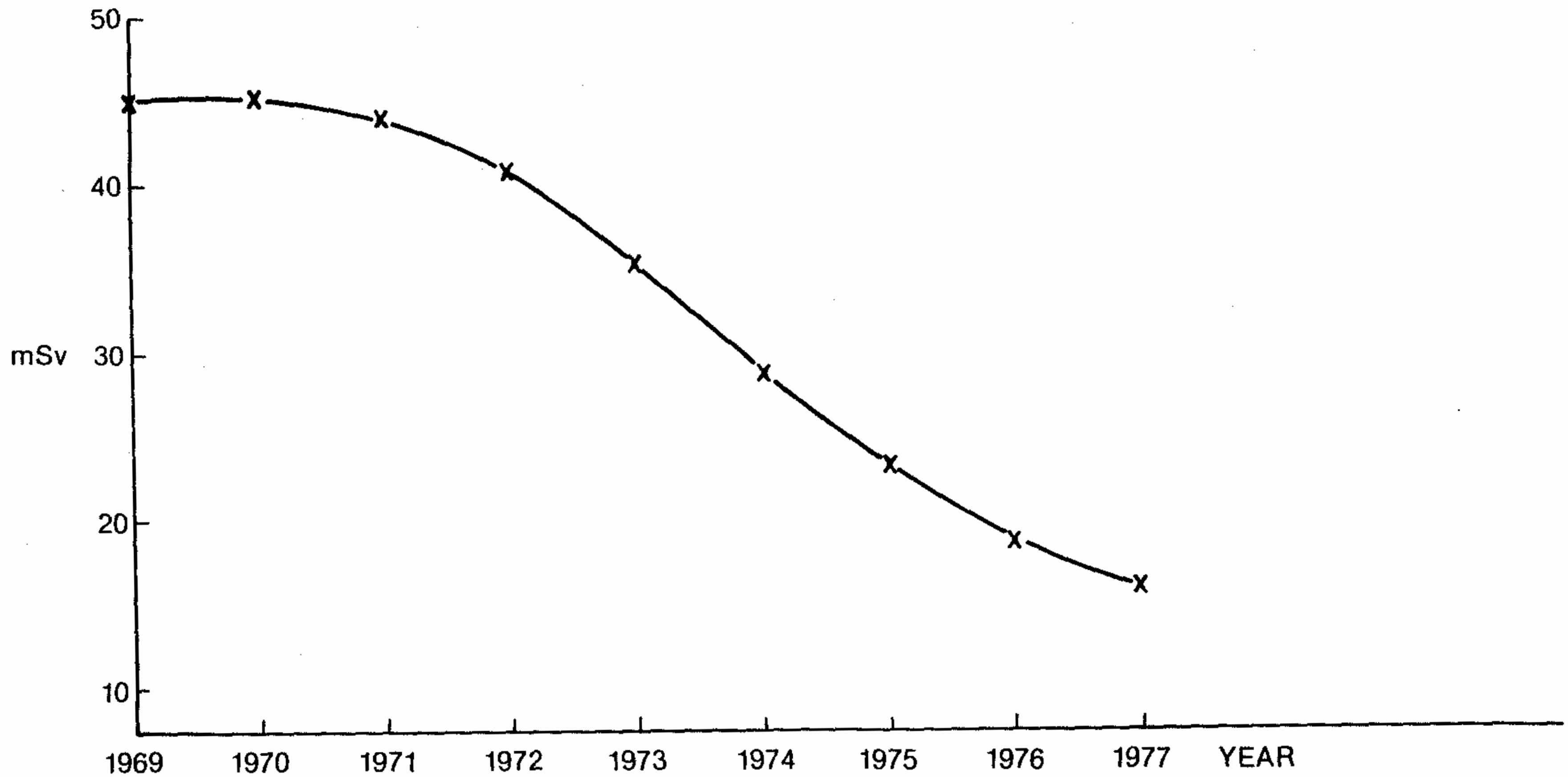

FIG. 5 AVERAGE INDUSTRIAL PERSONNEL WHOLE BODY EXPOSURE

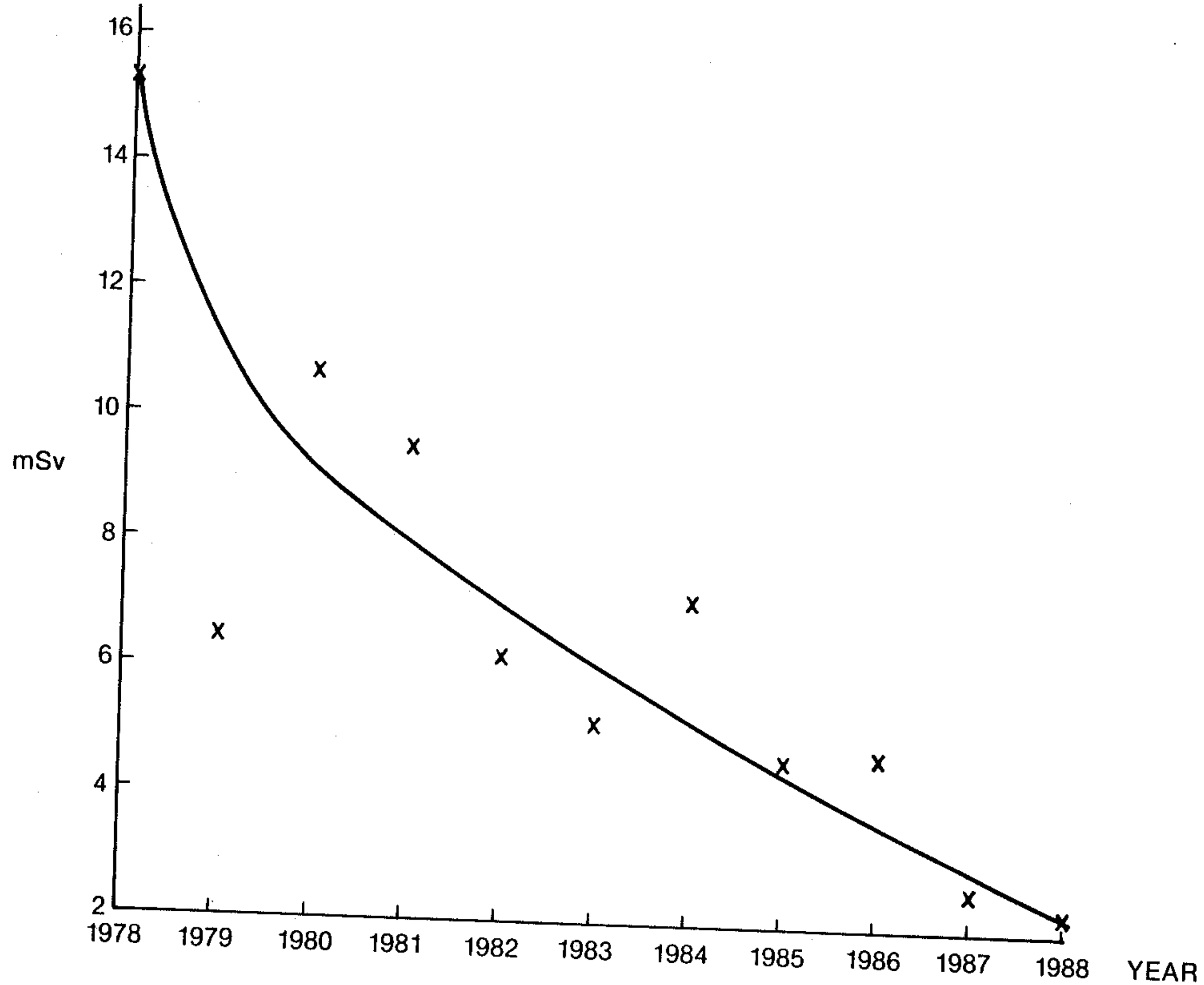

FIG. 6 AVERAGE PERSONNEL WHOLE BODY EXPOSURE

Calendar Year	1988	1987	1986	1985	1984	1983	1982	1981	1980	1979	1978
Total Dose (Man mSv)	193	193	367	350	490	360	450	650	620	393	780
Number of Staff	84	73	78	76	69	69	72	68	58	61	51
Number of Staff (and % of total) receiving doses in range:-											
0 – 4.9 mSv	80 (95)	70 (96)	43 (55)	46 (60)	33 (48)	41 (59)	33 (46)	17 (25)	16 (27)	28 (45)	19 (37)
5.0 – 9.9 mSv	4 (5)	3 (4)	27 (37)	20 (26)	16 (23)	19 (28)	27 (37)	24 (35)	12 (21)	26 (42)	
10.0 – 14.9 mSv	0	0	6 (8)	8 (11)	12 (17)	6 (9)	8 (11)	15 (23)	13 (23)	7 (11)	10 (20)
15.0 – 19.9 mSv	0	0	0	2 (3)	7 (10)	1 (1)	4 (6)	5 (7)	8 (14)	0	
20.0 – 29.0 mSv	0	0	0	0	1 (2)	2 (3)	0	7 (10)	9 (15)	0	20 (39)
> 30 mSv	0	0	0	0	0	0	0	0	0	0	2 (4)
Average Dose mSv	2.3	2.6	4.7	4.6	7.1	5.2	6.2	9.5	10.7	6.5	15.3

FIG. 7 DISTRIBUTION OF WHOLE BODY DOSE INCURRED IN A59 FOR THE YEARS 1978 to 1988 INCLUSIVE

Dose Range (mSv)		0 - 4.9	5.0 - 9.9	10 - 14.9	15.0 - 19.9	20 - 29.0
Non Industrial	1983	26	2	1	0	0
	1984	18	5	4	1	0
	1985	24	4	0	0	0
	1986	25	4	0	0	0
	1987	28	0	0	0	0
	1988	35	0	0	0	0
General Workers	1983	6	12	3	1	0
	1984	10	5	5	3	1
	1985	13	9	4	1	0
	1986	8	15	3	0	0
	1987	24	0	0	0	0
	1988	22	1	0	0	0
Mechanics	1983	8	2	1	0	0
	1984	3	5	2	0	0
	1985	3	5	3	1	0
	1986	5	6	2	0	0
	1987	11	0	0	0	0
	1988	10	1	0	0	0
ESB Electricians	1983	1	1	0	0	0
	1984	2	0	0	0	0
	1985	2	0	0	0	0
	1986	2	1	0	0	0
	1987	5	0	0	0	0
	1988	6	0	0	0	0
Decontamination	1983	0	1	0	0	2
	1984	0	0	0	3	0
	1985	1	2	1	0	0
	1986	1	2	1	0	0
	1987	1	2	0	0	0
	1988	2	2	0	0	0
Magnox Retrieval/CPDG	1983	0	1	1	0	0
	1984	0	1	1	0	0
	1985	3	0	0	0	0
	1986	2	1	0	0	0
	1987	1	1	0	0	0
	1988	5	0	0	0	0

FIG. 8 DISTRIBUTION OF WHOLE BODY DOSE BY WORKING CATEGORIES FOR 1983 TO 1988 (INCLUSIVE) NUMBER OF PERSONS

DISTRIBUTION

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4	Pott	Kernforschungsanlage Heibe Zellen D - 517 Julich
4	Carlsen	Danish National Laboratory RISØ Roskilde Danemark
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5	Trezza	ENEA S.P. Anguillarese PO Box 2400 00100 Roma A/D
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