

United Kingdom Atomic Energy Authority

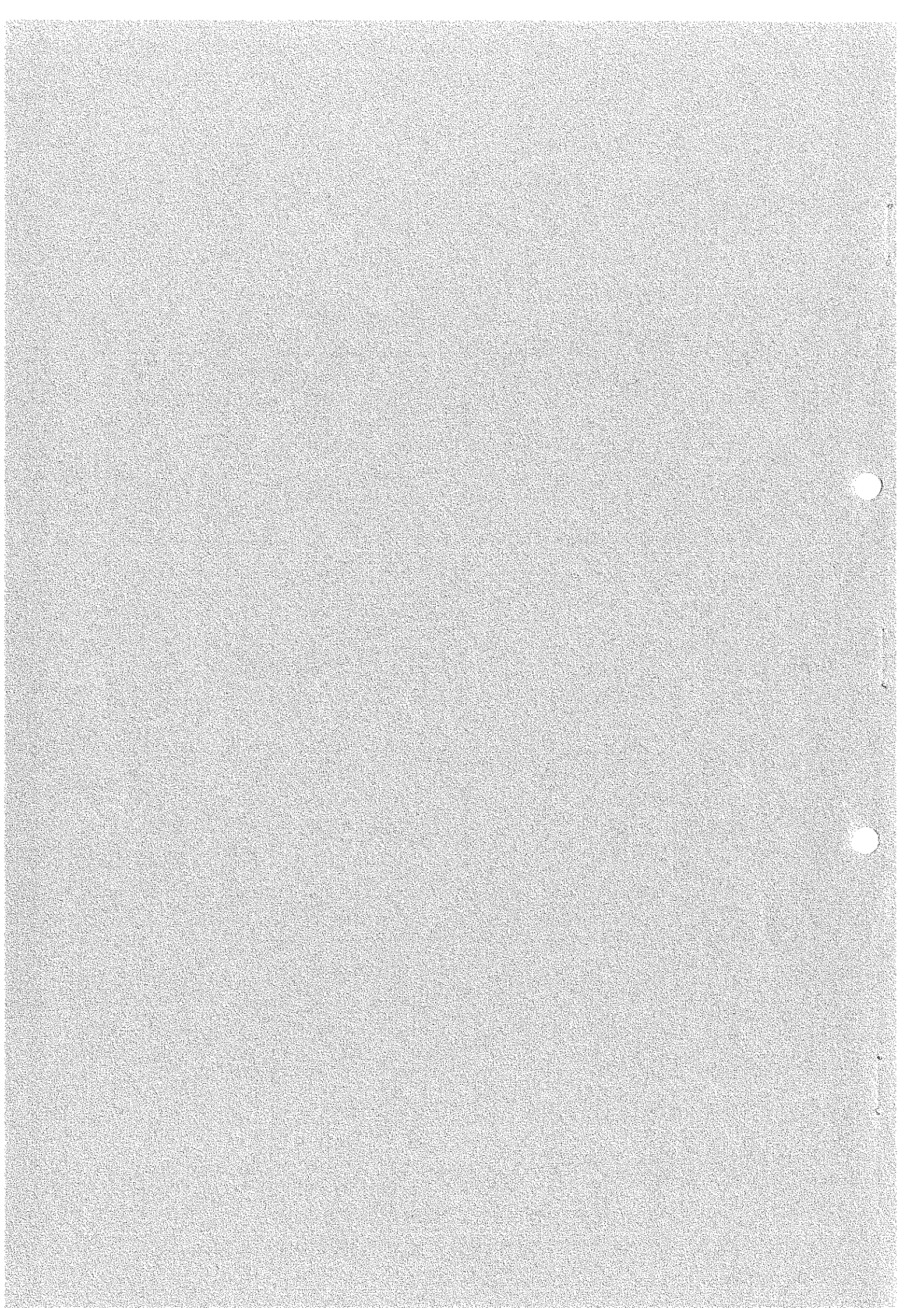
HARWELL

**E.E.C. C.C.R. Working Group
on Hot Laboratories and
Remote Handling**

**1979 Plenary Meeting –
Riso, Denmark**

**Current techniques and future
trends in decontamination of
hot cells and ancillary equip-
ment in the UKAEA**

S. L. Naylor and P. B. Reade



E.E.C. C.C.R. Working Group on
Hot Laboratories and Remote Handling
1979 Plenary Meeting - Riso, Denmark

Title Current techniques and future trends in
decontamination of hot cells and ancillary
equipment in the UKAEA.

Authors: S L Nayler and P B Reade

Abstract

Existing decontamination techniques in the UKAEA involve remote cleaning by cave operators using a variety of manipulators. When activity levels are as low as can be achieved by this method, intervention by air-suited men is usually necessary for further decontamination.

A new philosophy is required if the collective doses (Man-Rems) are to be significantly reduced. Decontamination to low activity levels should be possible using remote handling equipment so that operators or maintenance crews will not receive radiation doses even when intervention is necessary for removal or installation of equipment etc. The cell and its equipment should be designed with decontamination and subsequent disposal as a first consideration.

Contents

1. Introduction

2. Containment and Decontamination Techniques

- 2.1 Typical existing layout and design of hot cells.
- 2.2 Materials used and accessibility of manipulators.
- 2.3 Reasons for decontamination.
- 2.4 Existing decontamination methods.
- 2.5 Operator dose levels.
- 2.6 Problems encountered in decontaminating dry caves.
- 2.7 Methods of reducing and avoiding decontamination in cells.
- 2.8 Problems with wet facilities.

3. A suggested New Philosophy for Hot Cells

- 3.1 Design aims.
- 3.2 Objectives - Suggested rules to be followed.
- 3.3 Ultimate disposal.
- 3.4 Codes of Practice.

4. Typical design of New Cells

- 4.1 New radio-chemistry facilities.
- 4.2 Cell line layout.
- 4.3 Box removal.
- 4.4 Transfer to decontamination facility.
- 4.5 Introduction of clean box into cell.
- 4.6 Other design features.

5. Research and Development Policy

6. Conclusions

7. References

1. Introduction

1.1 The methods which have been used for decontaminating cells and equipment over the past 20-30 years are simple and sometimes crude. The cost in terms of money and operator dosage is comparatively high and the down time to effect decontamination, resulting in the loss of use of the facility, is very expensive. The down times quoted by various facility operators for decontamination range from 6 months to 2 years. These methods have been applied successfully over the years in limiting radiation doses to operators and maintenance staff to within the internationally accepted limits. However, there is in addition increasing pressure to implement more fully the ICRP recommendations that all operator doses be kept as low as reasonably achievable, economic and social factors being taken into account.

There is therefore a need to review, and improve, our methods and procedures for decontamination to achieve a reduction in doses and indeed to take a new look at the design of our facilities with decontamination and ultimate disposal in mind.

1.2 When planning new facilities it would be sensible to consider carefully the cell operations and maintenance such that contamination is minimised and even avoided if possible. Equipment and the facilities should be specified, and designed in such a way that decontamination, retrieval or disposal can be achieved, cheaply, quickly and at no risk to the operating and maintenance staff.

1.3 All materials used on the inside of cells should have high decontamination factors (DFs). The inner surfaces of the cell and equipment should be made of, or covered with, a radiation resistant material that can be either (a) easily decontaminated by simple methods without resorting to surface removal, or (b) an easily strippable material that presents no problems with spread of contamination or disposal. Sliding contact surfaces, lead screws and moving parts should, where possible, be contained within bellows or specially shaped tents. Equipment should be so designed that contamination cannot enter into crevices and the surfaces are smooth and contoured to facilitate easy remote cleaning. Great care must be taken to ensure that successful removal of contamination does not result in a much bigger problem of a larger volume of active waste.

1.4 Decontamination should be achieved by using remote techniques and as far as possible eliminate the necessity for intervention.

1.5 Some, if not all, of these principles have been suggested previously but have not been widely adopted in practice. This paper reviews current practice in the UKAEA and suggests lines of future development work into aspects of decontamination and the design of new facilities.

2. Containment and Decontamination Techniques

2.1 Typical existing layout and design of hot cells

Most of the hot cells built in the UK were designed between 15-25 years ago. The designers were far-seeing in as much that they designed for safety and flexibility to cope with a virtually unknown set of in-cell tasks. The fact that most of the facilities built in those times are still working safely is a great tribute to the original designers. It must be remembered that the majority of concrete-shielded cells were designed for handling beta gamma activity. Alpha activity was then minimal. Contamination was recognised and understood but little experience existed regarding its containment. Alpha activity usually existed without beta gamma activity being present and was contained in unshielded or lightly shielded glove or tong operated boxes. Typical concrete shielded hot cells of the period are shown on Fig I. The upper suite of cells is the High Active line consisting of 5 cells with 1627 mm (5' 6") thick concrete walls, zinc bromide windows and Master Slave Manipulators (MSMs), and a Power Manipulator. The lower suite is the Medium Active line with 1220 mm (4 ft) thick walls. Some cells have zinc bromide, others block glass windows with MSMs and a power manipulator. The space between cells is for flask transfers and maintenance. The walls between cells are removable to allow internal transfers and passage way for the power manipulator and hoist.

2.2 Materials used and range of accessibility of Manipulator

The internal surfaces of the cells are lined with mild steel plate and coated with epoxy paint. This paint has proved very successful over the many years of service in active conditions. On one occasion when the cells became contaminated with Sr_{90} in the form of a dust, it was decided to attempt its removal by remotely applying strippable lacquer over the surfaces. In those cells where activity was relatively low the lacquer stripped off like rolls of wallpaper and brought with it most of the activity. In the cell where activity was fairly high the strippable lacquer could not be readily removed. The lacquer had become polymerised in a few hours and was so hardened it had to be scraped off and the whole of the cell surfaces reduced to bare metal. The exercise involved the use of strong paint strippers and intervention to completely remove the lacquer and epoxy paint.

In order to decontaminate cell surfaces or equipment in the cell remotely full use of the through the wall manipulators is essential. Within the normal range of the through the wall manipulators the surfaces and equipment can be reasonably dealt with, but outside their range, the power manipulator must be used. There are many areas which cannot be adequately reached, which means that the remaining contamination can only be removed by the intervention of air-suited operators. This type of intervention is one of the major causes of operator dosage. Older facilities tended to have conduits and service outlets mounted on the inner surfaces of the cells and great difficulty has been experienced in removing decontamination from around and behind this equipment⁽⁴⁾

2.3 Reasons for Decontamination and Existing Methods

2.3.1 It is perhaps necessary to consider what has to be decontaminated before discussing the reasons for doing this work which is expensive and could be hazardous, these are:

- (a) Caves and cells, which provide shielding for protection, may be lined directly on the inner walls to form a decontaminable barrier, or have a separate metal box with an air gap between it and the shielding.
- (b) Equipment and tools used for carrying out the work of the cave or cell and includes instruments.
- (c) Radioactive sources and reactor fuel which may be required for production or research and development, and
- (d) Active waste which is produced in carrying out work in caves and cells. This waste may or may not have to be conditioned to reduce its activity or bulk, but it is packaged and where necessary, shielded.

All of these items require decontamination in some form and to a lesser or greater degree dependent upon their final destination.

2.3.2 Decontamination processes usually tend to disperse or dilute the contamination and increase the volume. Present methods also often expose staff to radiation during decontamination periods. It is very important to be certain that the reasons for doing this work are valid and that advantages and cost benefits outweigh the disadvantages and expenses.⁽¹⁾

Some of the reasons given for decontamination are listed below:-

- 2.3.3 It is necessary to decontaminate equipment so that it can be approached and handled for maintenance, repair or modification. This procedure is adopted when the equipment is expensive or large and difficult to handle, and avoids it becoming active waste. An example is the decontamination of manipulators, the efficient cleaning of which allows better maintenance and less breakdown frequency.⁽²⁾
- 2.3.4 Early removal of contamination may prevent special facilities being made unusable; e.g. the removal of acid from fuel elements at an early stage avoids contamination of flasks, posting facilities and caves.
- 2.3.5 Decontamination can separate different types of activity, the most obvious example being the separation of fission products during reprocessing.
- 2.3.6 The cost of subsequent processes may be reduced following a decontamination stage, i.e. less shielding may be required. Similarly, contaminated waste can be treated such that it can be disposed of via a cheaper route.
- 2.3.7 Contamination can cause exposure to operators and damage to organic materials if left in place.

- 2.3.8 Regulations which specify that surface contamination is reduced to specified levels before equipment may leave the facilities, e.g. transport flasks and specialised equipment requiring maintenance off site.
- 2.3.9 Decontamination may be necessary to avoid activity release into the environment, e.g. changing filters.
- 2.3.10 It may be necessary to decontaminate an area so that accurate measurements of the radioactivity from some source may be made.
- 2.3.11 The final disposal of a contaminated facility, or piece of equipment, will require a decontamination campaign.
- 2.3.12 Timely decontamination may limit radioactive events during which unpleasant products "grow in", e.g. Americium 241.
- 2.3.13 Decontamination is sometimes used as part of campaigns to recover fissile material.
- 2.3.14 Following incidents, it may be necessary to decontaminate the working area, e.g. if a glove bursts, surrounding areas have to be decontaminated.
- 2.3.15 In chemical analysis work it is often necessary to decontaminate the working area of a cell to prevent cross contamination between cells.

2.4 Existing Decontamination Techniques

- 2.4.1 The large undivided type cells lined with steel against the concrete shielding walls were designed for maximum flexibility to deal with a wide range of production and research work. In conjunction with windows, MSMs, a power manipulator and hoist, transfers within the cell were intended to be as simple as possible. This layout, however, allowed the spread of contamination within the cell. In order to reduce contamination spread the large cell area was subdivided by part-fixed walls and part-sliding door. There was no real containment of each individual cell. More reliance was placed upon the air flows and the cell depression to localise the spread of any contamination.
- 2.4.2 In the early days of cell design there was insignificant alpha activity and so the emphasis was not upon high integrity containment. Most cells were designed mainly for beta gamma work. The integrity of the system relied upon the following:-
 - (a) A negative air pressure of about 25 mm W.G. (1") with the ability to increase this in the event of an incident.
 - (b) High number of air changes up to 20/hr.
 - (c) Air flow directions generally downwards to filtered extracts and away from penetrations.
 - (d) Gaiters on MSMs and Power Manipulators as a seal and contamination control.

- (e) A velocity of 1m/sec (200 ft/min) across any opening into the cell.
- (f) Strict control of cascade ventilation from clean areas progressively to high active areas also ensuring no two openings in adjacent zones were opened at the same time.

2.4.3 Decontamination used in its widest sense may involve the following methods:-

- (a) Loose contamination can be removed by using dry methods such as, brushing, collecting on sticky cloth, vacuum cleaning and swabbing.
- (b) Similarly, further removal of contamination can be by wet methods using water jets, steam lances, scrubbing with water and detergents.
- (c) Surface removal with high pressure water jets, shot, grit, or glass bead blasting, machining or grinding. Chemical attack also with electrolysis. Coated surfaces such as paints may also be removed by the methods above. Surfaces may be removed by flame spalling.
- (d) Other techniques which may be used involve the evaporation of volatiles, layer removal where strip coatings have been used, and immersion in baths using ultrasonics.
- (e) Gases may be decontaminated by some of the following methods:- filtration, gettering, absorption on charcoal, electrostatic collection and cryogenic separation.
- (f) The decontamination of liquids is possible using one of a selection of methods depending upon the solution to be treated:- filtration including suction devices, floc treatment, precipitation and filtration, distillation, ion exchange, electrolysis, solvent extraction, magnetic separation, cold and hot trapping, drying, and surface run-off over a weir.

It is recommended that the least disturbing and simplest methods are used for decontamination in the first instances. The cost of decontamination must be weighed carefully against the benefits gained. If during the treatment of small objects the concentrated contamination is transferred to a much larger volume requiring further treatment, the costs in time, money, resources and man-rem exposure are increased.

2.5 Operator dose levels

- 2.5.1 Decontamination occurs in caves usually from two main causes, (a) external surface deposits (e.g. crud) may be knocked off or fall from a component, (b) when fuel and metals are cut, Contamination will be spread over a wide area of the cave. Using current equipment and techniques the release of a few grammes of radioactive material into a cave means irrevocably that a considerable amount of money must be spent during decontamination processes, and that eventually personnel will be required to enter the cave and receive some radiation dose.
- 2.5.2 A moderately 'dirty' cave will require several weeks to clean it to a reasonable standard before entry for maintenance can be considered.

Experience has shown that the contamination of a cave is probably equivalent to committing approximately £20,000, not counting the loss of facilities costs, when a clean-up programme is embarked upon. It must also be remembered that work carried out by men wearing protective clothing reduces a man's output to less than 30% of normal.

- 2.5.3 The Management of active buildings work to within the ICRP and local recommendations and regulation of 5 Man Rems/year. As an example, in 1977 the total dose accrued by ten cell operatives working in a typical high activity facility at Harwell amounted to 18.12 Rems, i.e. an average of 1.81 Rem/year, with a maximum for any individual of 2.59 Rems. From measurements taken at the surface of the cell windows it is estimated that the dose received by the ten operators whilst working at the cell face only would total 1.7 Rem, i.e. an average of 0.17 Rem/man.

The difference, 16.46 Rems, would be accrued in carrying out flask and contaminated equipment handling and cell intervention. In 1977 the total dose attributed to cell entries alone was 8.32 Rems. Expressed as an average per operator the dosages were:-

Cell face operations	0.17 Rems
Transfer operations	0.30 "
Cell intervention	0.83 "
Handling contaminated equipment	0.51 "
	1.81 Rems

2.6 Problems encountered in decontaminating Dry Caves

- 2.6.1 When cave operators decide to remove a few grammes of active material from their facility they encounter numerous difficulties. Small particulate activity is almost invisible and is difficult to locate with monitors. Even well-designed and built caves are often full of nooks and crannies into which active particles settle, thus making their location and removal onerous.
- 2.6.2 The choice of cleaning methods is important, because a wrong judgement may spread the activity over a wider area. Work is then escalated into chasing less and less activity over larger areas. Even the tools and equipment used for decontamination become contaminated despite operator skills.
- 2.6.3 Extract ventilation filters often present problems because they become active and are relatively large objects. A decision is required when to shut-off ventilation and change filters. In fact most filters are changed when the pressure drop is considered high, not because the activity has reached a certain level.
- 2.6.4 Decontamination waste, emanating from cells and caves after clean-up campaigns, is usually of considerable volume, and rarely receives any further treatment to reduce the volume prior to packaging for disposal. This all requires shielding which adds considerable mass so that the total weight of material from a single cave clean-up requiring disposal can amount to many tonnes.

2.7 Methods of reducing and avoiding contamination

2. 7.1 In any cave system there are some simple rules which when applied could help to reduce contamination, problems, costs and radiation dosage to personnel:-

- (a) Remove all known sources of radioactivity to a separately shielded store.
- (b) Vacuum clean very thoroughly and efficiently all the surfaces of the cave.
- (c) Remove all the equipment into an enclosed cleaning booth.
- (d) Clean the bench using a minimum amount of water and detergents, to less than 10 m Rem/hr.
- (e) Any "hot-spots" associated with fixed contamination should be quickly identified and shielded to enable subsequent removal by appropriate surface treatment.
- (f) Prevention is better than a cure, so if crud is present on fuel elements it should be removed, unless it is itself to be the subject of examination, into a special facility prior to posting them into caves.
- (g) It is estimated that the full implementation of the above measures involving the provision of more advanced and efficient caves and equipment would reduce the time for decontamination by a factor of 2 and the total operator Man Rems by a factor of 5.

2.7.2 Metallography cells present a different problem since they are both 'wet' and 'dry' in their designation. Grinding and polishing is perhaps the most difficult to deal with from a decontamination viewpoint. However, two suggestions are put forward for consideration

- (a) Decide if the process is 'wet' or 'dry' and keep to whichever is decided upon and design the equipment accordingly.
- (b) Localise and enclose the contamination e.g. cutting should be done in separate small cell with specialised equipment to prevent contamination spread and have first class clean-up facilities.

2.8 Problems with 'Wet' Facilities

2.8.1 Fuel reprocessing is perhaps the major plant which contains 'wet' facilities. This plant consists of process vessels, pipework, valves, pumps etc typical of a chemical plant. The nature of the plant and equipment rule out the use of the type of decontamination equipment used in caves and cells. An entirely different approach has to be made. Normally the plants are decontaminated in-situ, but if so designed for remote dismantling, could be removed to a decontamination centre. Experience with 'highly active' chemical process, shows that decontamination is a very long process involving months of work before it can be reduced to safe man entry levels. Fortunately 'wet' plants do not usually require to be decontaminated so frequently as 'dry' ones.

2.8.2 The standard of construction of plants may have some significance in the ease or difficulty with which decontamination is carried out. Rough handling on site, poor workmanship in welding and fitting has occurred at most sites when the highest of standards of equipment and workmanship is required. However, no quantified evidence has been collected to prove that these shortcomings really affect the levels of contamination but opinions of many experienced staff tend to confirm these statements.

2.8.3 The problems are associated with the decontamination of metals, concrete and coated surfaces, in particular stainless steel which is widely used in chemical plants and cells. Stainless steel is chosen mainly because of its corrosion resistance, cost and general familiarity with this group of materials. Contamination of stainless steel by active agents occurs in the upper surface oxide films, the chemistry of which is not fully understood. There are indications that the type of surface finish is more important than was first believed. e.g. Electrolytic polishing may not provide a mirror finish as obtained by mechanical polishing, but indications are that the surface of the former is easier to decontaminate (7). Fixed contamination on metal surfaces can only be reduced by surface removal chemically or mechanically. Recent investigations of possible decontamination treatments for major chemical plant at Windscale indicate that it is possible to decontaminate to general radiation levels of 25-100 mR/hr, but "hot-spots" of 10-20 rem/hr decontamination, local shielding or vessel removal.

may remain which can only be dealt with by very intense

The most effective chemical treatments for stainless steel decontamination are:-

- (a) Alternate nitric acid and sodium hydroxide.
- (b) Alternate nitric acid and oxalate/citrate/peroxide.
- (c) Alternate nitric acid and tartrates/hydroxide/peroxide.
- (d) Alternate alkaline permanganate and oxalic acid.
- (e) Fluoride/nitric acid.

2.8.4 Painted surfaces should only be chosen for very light duties i.e. where there is little risk of mechanical and chemical damage and where radiation damage is slight. Paint should only be used where its regular removal and renewal presents no problems.

2.8.5 One of the most useful construction materials is concrete and this has been widely used. Concrete has many very attractive properties, the main ones being low cost, stability, corrosive resistance both wet and dry, and the ease with which it can be used. There are many pitfalls which are not generally appreciated however. Concrete is not impervious to gases or liquids, and its surface usually contains cracks and holes into which activity can seep or diffuse and become trapped. Once it has become contaminated, concrete cannot be readily cleaned and must therefore be disposed of as active waste. Concrete should only be used where there is little or no risk of it becoming contaminated.

2.8.6 Part of the P.F.R. programme at Dounreay involved the decontamination of fuel pin cladding for examination by electron microscopy (8). Oxide fuels are cut into small sections approximately 0.6 cm long and defuelled by dissolution in nitric acid. Carbide fuels however have to be defuelled mechanically using special drilling techniques. These sections are 0.6 cms long and any remaining fuel is removed by dissolution in acid. In order to decontaminate them further the sections are passed into a decontamination cell where they are agitated ultrasonically in special strong detergent. The citric acid concentration was 20 gms/litre of water and the detergent "Teepol" was 10% volume in water. Latterly, this solution has been replaced by proprietary materials such as Decon 90 or Quadralene.

The best results were obtained with a cascade system, where the items are exposed to progressively cleaner solutions.

2.8.7 The chemical breakdown of materials for examination which may contain alpha, beta, gamma and neutron emitting radioactive species is carried out in facilities at Harwell⁽⁹⁾. As well as the usual requirements of containment, general durability, and ease of decontamination, the in-cell components, equipment, and manipulator materials must be able to resist attack from a range of acidic materials which are capable of dissolving even resistant materials. The following principles have been developed:-

- (a) Careful containment of the acid materials and dissolution procedures. This necessitates the use of water and air-cooled vapour condensing arrangements, and solid absorbant traps such as soda lime, charcoal etc.
- (b) Extensive use of plastic covered surfaces on top of stainless steel containment. Vertical surfaces covered with chlorinated rubber strippable paint coats to trap radioactivity. Working surfaces are of rigid PVC sectioned for containment in case of incidents.
- (c) Strict control of high air flows, distribution, and input and output air filters, to ensure no high concentrations of acid fumes.

Glassware is used on a once-through basis because decontamination is impracticable. Cellulose absorbants are used to mop-up liquid spillages. General decontamination is carried out regularly over all working surfaces using detergent complexing agents on absorbant pads. "Hot spots" are treated with either abrasives or acid solutions. Loose particulate matter is collected via a miniature vacuum cleaner. The high specific activity solutions from the analysis process are neutralised and solidified using lime and cement. These blocks are packaged in sealed cans and sent for disposal. The facility works well and has been successful in its complete system concept from input to disposal.

3. A suggested new philosophy for Hot Cells

3.1 The design philosophy of any new hot cell facility should include among its principal aims the control of contaminants within the containment, ease of decontamination of equipment and all internal surfaces and the ultimate disposal of the total facility.

3.2 It is suggested that the following objectives should be met when designing and operating new facilities:-

- (a) Facilities should be designed for operation, decontamination and dismantling without man entry. Provision should be made for man entry but this should normally be used only after radiation levels have been reduced to very low values by remote methods.
- (b) It should be possible to see and reach every part of the cell remotely.
- (c) The remote handling equipment should be safe, reliable, and capable of reaching everywhere in the cell, be easily operable and at the same time easily decontaminable.

- (d) All equipment and tools in the cell should be modular and each module remotely replaceable.
- (e) Equipment and surfaces should have no nooks or crannies, but be smooth and contoured for easy cleaning. Any moving or sliding parts should be separately enclosed with easy removable dust-tight covers.
- (f) Materials used in-cell should have high decontamination factors (DFs).
- (g) No services or equipment shall be fixed to the inside of a box or cell.
- (h) A smooth, clean surface with a high DF is preferred for cells and caves, but if this is not possible the alternative is an easily strippable coating which is also easy to dispose of when removed.
- (j) Each cell should have access to light-weight, portable, efficient decontamination and cleaning equipment, e.g. filtered vacuum cleaner, filtered vacuum scrubbing unit with ability to inject various cleaning fluids.
- (k) Ventilation should provide, as near as possible, laminar flow from high to low level in order to keep contamination on the lower surfaces. Depression should never be less than 15 mm water gauge. Flow velocities should be selected to ensure uniform scavenging of the cell with the extract at cell work face level at the sides and rear with easy remote change of HEPA filters.
- (l) Window and cell lighting should be designed in conjunction with each other and should be tested out in a mock up to select the best combination.
- (m) Decontamination should be carried out every day or after each specific job whichever is the sooner.
- (n) Prevention of decontamination is better than successful clean-up after contamination, e.g. removal of crud from fuel pins before examination in-cell. Also local containment of 'dirty' processes.
- (o) Facilities should be designed to ensure reductions to minimum levels of accumulated radiation doses to operator and maintenance staff consistent with economic design.

3.3 Ultimate disposal of facilities could be very difficult for staff who in later years inherit the buildings and equipment, therefore much more thought and design effort should be given to decommissioning. No equipment should be designed and made unless its final disposal is clearly established. Similarly, cave and cell linings or boxes should be decontaminable and reducible to a disposable size. If good "housekeeping" has been practised in the cave, the remaining shielding walls should not be contaminated. After the removal of all contaminated items, the lead, steel, or concrete shielding duly sealed should be clean enough for removal by labour working in normal clean conditions. It also follows that the building itself should be clean and can either be reused or disposed of, if necessary.

3.4 Codes of Practice

Much information exists in the published literature on methods of decontamination and the UKAEA and BNFL have recently produced a draft Code of Practice on Radioactive Decontamination (Ref Atomic Energy Code of Practice on Radioactive Decontamination AECP 1057 UKAEA 1977). This document has been prepared in collaboration with the major nuclear organisations in Great Britain, for example, Central Electricity Generating Board, Nuclear Power Company, British Nuclear Fuels Ltd, MOD, and the United Kingdom Atomic Energy Authority. It covers the mechanisms of contamination and decontamination, methods of decontamination, design of plant and equipment for decontamination. As a large proportion of decontamination work is carried out by direct handling, a great deal of consideration has been given to health physics criteria and control of radiation dosages. Because of the increasing emphasis on reducing radiation dosages to personnel there is now a need to extend the scope of this code of practice to include recommendations on equipment, techniques and methods for carrying out remote decontamination.

4. Typical Design of New Cells

4.1 New Radiochemistry facilities are being designed at Harwell consisting of a line of 5 shielded cells and a larger cell at the end to be used for box handling, decontamination, waste handling and packaging. At the side of the large cell is a glove box maintenance facility ⁽⁶⁾.

4.2 The suite of cells will have removable boxes with self-sealing couplings to isolate services to the box and at the box. A special lift-off trolley is used to disconnect the box and lift it on its rear shielding for removal and replacement. This is a new departure for the U.K., but has been successfully used in Germany and other countries. All connections and disconnections are carried out remotely without exposing staff to radiation. Fig 2.

4.3 When an experiment or work schedule has been completed it will be necessary to remove the box from its cell. Fig 3. At the same time the rear shield door to the decontamination suite is opened.

4.4 The crane picks up the box from its shielding door lifts, rotates it through 180° and lowers it onto the decontamination suite shielding door. Fig 4.

4.5 The crane is moved away from the decontamination suite, whose door can now be closed. This seals the box into a separate cell which will allow clean-up and removal of the redundant equipment in the box. In this position the rear panel of the box can be removed remotely by the front face operating manipulators, allowing full access into the box. There are also manipulators in the rear shielding door assisting in decontamination and equipment removal. Once the large cell door is closed, the crane can be used to pick up a clean box containing a new experiment and assist in installing it in the vacated cell. Fig 5.

The complete operation can be carried out remotely without radiation exposure to the staff.

4.6 Other features of the cell design which have been adopted to reduce the spread of contamination include:-

- (a) Double cover posting systems at the cell rear.
- (b) No inter-cell communication except via suitable air locks to prevent cross contamination.
- (c) Proposed cell and equipment materials to have high DFs, easy decontamination and disposal.
- (d) In-cell safe filter change using a newly developed filter and simple remote change system.
- (e) Use of double separation manipulators so that the "hot arm" remains in the box when the box is removed, leaving both exposed ends sealed. The "hot arm" can also be lifted off inside when the box is cleared in the decontamination cell, leaving a seal in the box face.
- (f) The design of the cell complex structure is such that it is modular and could be enlarged to form a very big single undivided cell. Alternatively the concrete beams, roof slabs and walls could be dismantled and removed, in fact completely decommissioned by normal labour.

5. Research and Development

Although the general principles which are recommended for the design of new active facilities can be stated fairly simply as in Section 3 of this paper there is a great deal of research and development which should be done to ensure successful attainment of the stated objectives. The following areas of R&D have been identified and work has started on some of these in U.K.A.E.A. Programmes for others are being considered but many of the items listed have yet to be started.

- (a) Research into the nature of surface contamination by radioactive species and the physical and chemical bonding phenomena.
- (b) Characterisation of all known radioactive contaminants and how they contaminate.
- (c) New materials whose surface is resistant to contamination and is easily cleaned.
- (d) Surface finishes which are resistant to contamination and are easily cleaned or removable and present no disposal problems.
- (e) Instruments which can detect, locate and measure contamination accurately. Simple, portable instruments which are easy to read and use are needed.
- (f) The protection of concrete which isolates it from both dry and wet contaminating environments.
- (g) Radiation and contamination resistant plastics, particularly for clear visibility.
- (h) New decontamination techniques or the development of existing ones. Development of data, methods and practices which states how to deal with all types of contaminants and surfaces.

- (j) Development of decontamination equipment for use in cells and the treatment of waste e.g. small portable filtered efficient vacuum cleaning equipment, small remote use vacuum scrubbing machines with injection of various fluids, ultrasonic cleaners, electro-chemical decontamination and small re-circulating vacuum grit blasters.
- (k) Development of new remote handling equipment.
- (l) Development of ventilation systems inside cells which minimises contamination spread. Establish the significance of velocity, air distribution, flow direction and filtered re-circulation systems.
- (m) Separation of contamination from wet decontamination fluids.
- (n) Safe reduction of waste without spreading or contaminating the equipment.

6. Conclusions

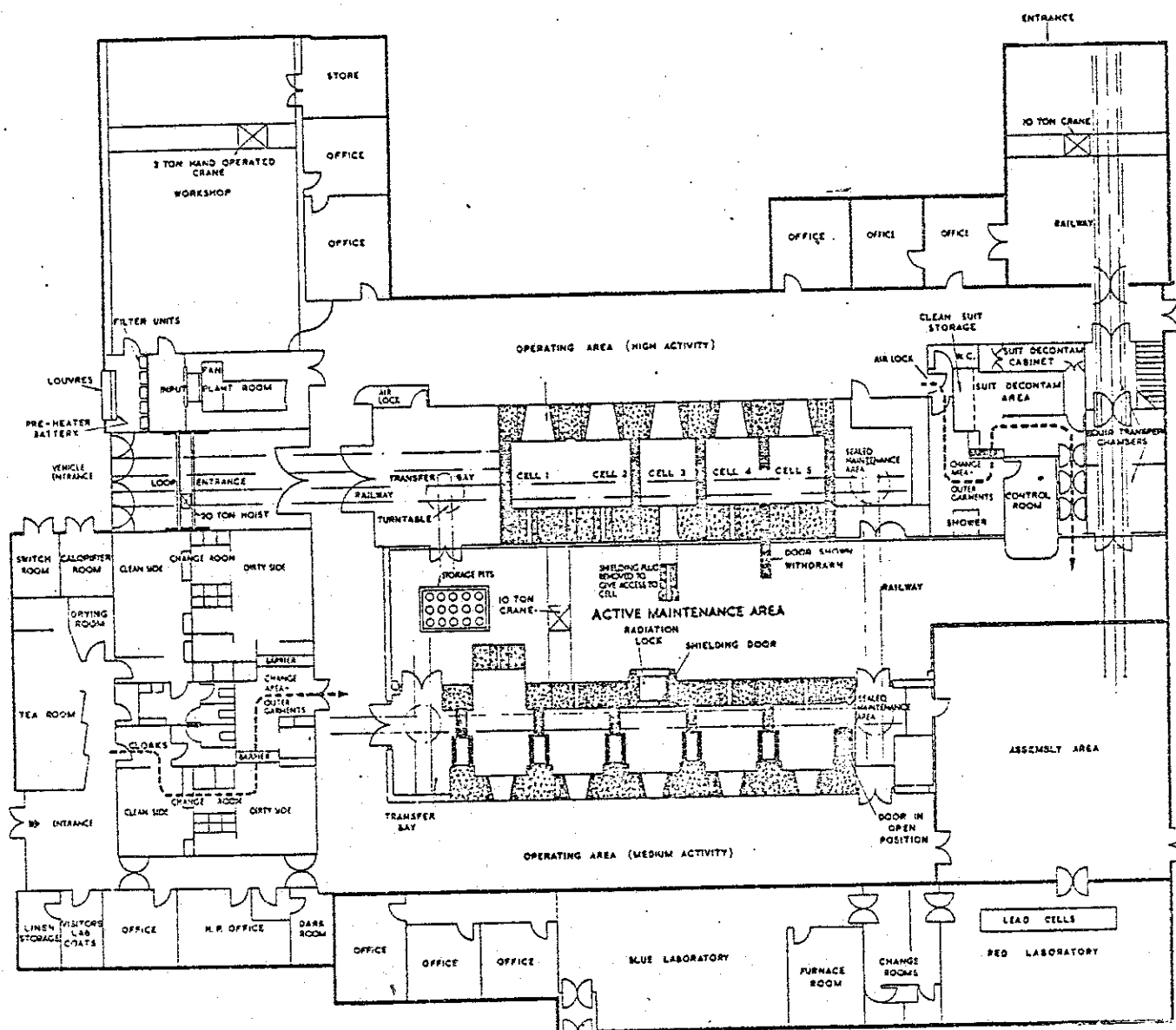
The methods used for decontaminating hot cells and equipment have changed little over the past twenty years or so. Improvements have been made, for instance, in the choice of decontaminating agents and in the development of particular pieces of equipment for use in specific in-cell situations. However, no major advances have been made towards a radical improvement in decontamination methods which would reduce operator doses. This situation is recognised within the UKAEA and designers are now including as an essential part of their brief the need to properly cater for improved methods of decontamination of both cells and equipment during normal operation and for the purposes of ultimate disposal. To assist designers in this task, some basic research is required, e.g. into the mechanism of contamination of surfaces, and programmes are currently being formulated or discussed. There is, in addition, the need for development of surface decontamination methods and equipment which will allow decontamination of in-cell surfaces to levels of say <10 mRem/hr by remote means, in particular the fundamental surface and material studies.

Some of this work could well be shared between the European organisations participating in this conference.

, in particular, the fundamental surface and material studies

7. References

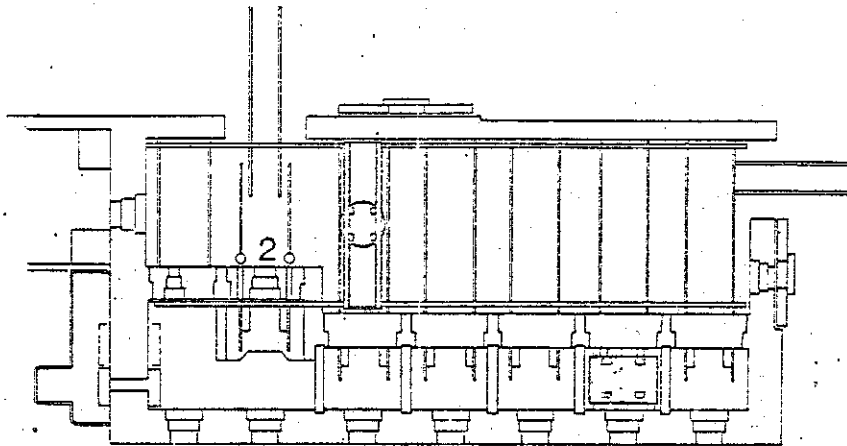
1. Dr S A Cottrell, (UKAEA Winfrith), Decontamination.
A review of problems and some suggestions for future R & D work (unpublished information).
2. M A Ryz (ACEL) Proceedings of 25th Conference on Remote Systems Technology 1977. A remote decontamination facility for Manipulators (ANS Winter Meeting).
3. AECP 1002 (UKAEA) Atomic Energy Code of Practice July 1976. The coating of surfaces requiring decontamination.
4. G D Button and A L Sullivan (UKAEA Harwell) Decontamination and decommissioning of cells, March 1979 (unpublished papers).
5. A B Ritchie (UKAEA Harwell) Operator dose rates at Harwell, part of paper presented by Dr M D Jepson to PIE Scientists Liaison Committee, September 1978.
6. D Campbell (UKAEA Harwell) Specifications for alpha, beta, gamma Radiochemistry Active Facilities at Harwell, 1976. (Unpublished information).
7. W J McTegart The Electrolytic and Chemical Polishing of Metals in Research and Industry. Pergamon Press.
8. E J Fulton and G Cawthorn (UKAEA Dounreay) Examination of irradiated reactor cladding and structural materials by electron microscopy BNES 1972.
9. Dr A J Fudge (UKAEA Harwell) Aspects of remote handling, decontamination and waste disposal for the chemical analysis of irradiated materials, March 1979. (Private communication).



LAYOUT OF A TYPICAL HIGH ACTIVITY HANDLING BUILDING

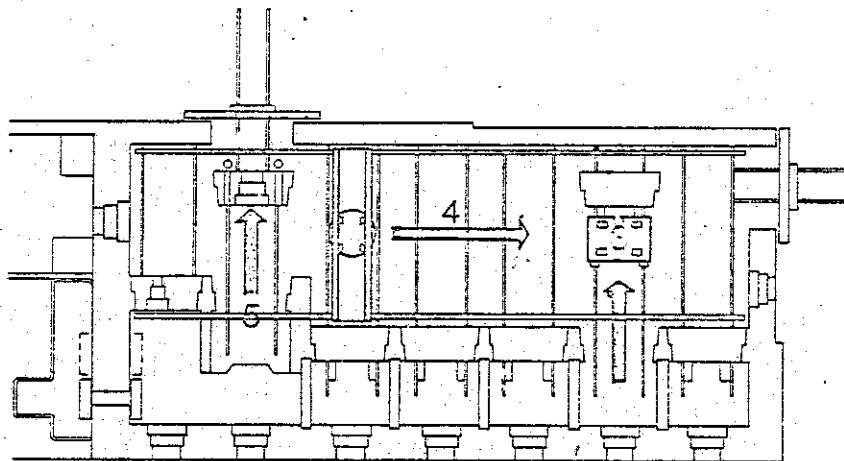
FIG. 1

**Fig 2, Normal Operating Conditions
[Access Doors Open to Area]**



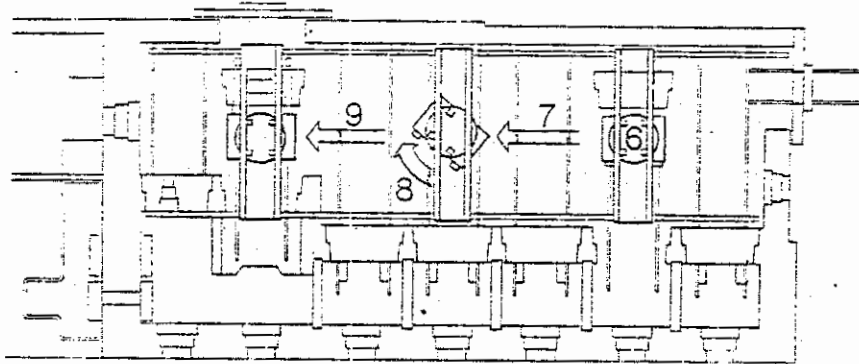
1. Box in Cell 2. Decontamination Cell Closed

**Fig 3, Withdrawal of Box
(Area Cleared Access Doors Closed)**



3. Cell Door Withdraws Carrying Box 5. Door to Decontamination
4. Crane Traverses Towards Box Cell Moved to Open Position
Ready to Receive Box

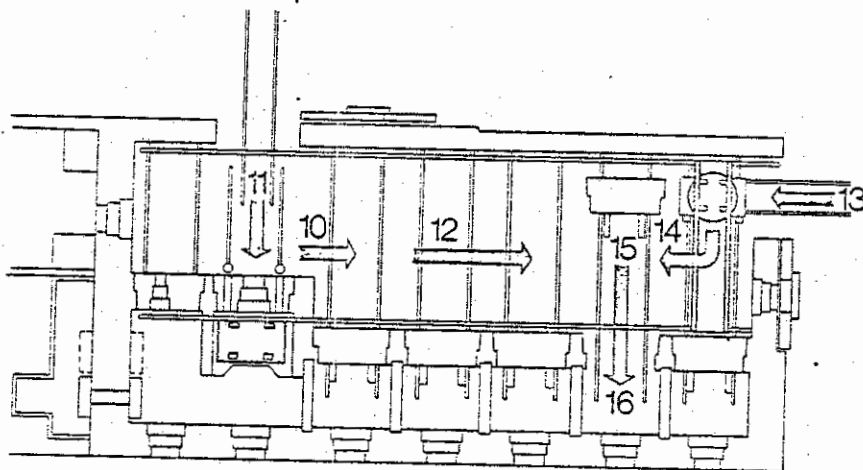
**Fig 4. Transit and Turning of Box
(Area Cleared Access Doors Closed)**



- 6. Crane/Turntable Engages with and Picks Up Box
- 7. Crane Traverses to Clear Space

- 8. Box Rotated Through 180°
- 9. Crane Traverses To and Places Box Onto Decontam Cell Door Arms

Fig 5. Box To Decontam Cell / Crane To Pick Up New Box (Area Available Doors Open)



- 10. Crane Moves Clear of Decontam Door
- 11. Decontam Door & Box Move into Decontam Cell
- 12. Crane Traverses into Position to Pick Up Incoming

- 13. Clean Box
- 14. Turntable Traverses and Crane Traverses to
- 15. Deposit New Box on Cell Door
- 16. Door and Box Move Into Cell
- Area Free for Working In

