

The Flask Leak Instrumented Test Equipment : FLITE

Winfrith has many years of experience in the design and manufacture of instrumentation requiring a high degree of accuracy, repeatability and reliability. Initially aimed at the nuclear industry many of the techniques developed also have application in other areas, notably the petroleum industry.

Winfrith's portable Flask Leak Instrumented Test Equipment (FLITE), specifically designed to meet the rigorous requirements of the AECP 1068 standards, is a unique automatic multi-channel measurement system. Originally designed for testing UKAEA modular fuel flasks, it is versatile enough to be applied to any container having double O-ring seal interfaces.

Tested both at Winfrith and Windscale, FLITE has proved highly reliable in calculating standardised leak rate and interspace volume to within +/- 10% on a 1×10^{-5} bar ml/s standardised leak rate.

Technique.

Flask leakage is measured from the pressurized interspace between seals. Over a period of 30 minutes the pressure in a 40ml flask seal interspace, usually set at 2.0 barA (approx), will fall by only around 1.07 mb. Any system for measuring so small a pressure drop, if it is to be internationally acceptable, needs to do so to within about 50 microbar, calling for the highest quality of transducers and the use of precision measuring techniques.

A fundamental problem is that the true volume of the interspace is not known with any accuracy, and earlier determinations of the leak rate have had to use an estimated value. If these very low leak rates are to be measured reliably an interspace volume of 50ml needs to be known to within about 0.3 ml.

FLITE

FLITE works on the principle of merging a known standard volume with the seal interspace volume and measuring the resulting pressure change. In this way the leak rate can be found regardless of the interspace volume, which can vary with the degree of seal tightening. A measurement of the interspace volume is also obtained thereby providing an independent check on the procedure.

The techniques involved in the measurement and calculation of these low leak rates must be validated to show that the results are reliable and conform to Quality Assurance requirements. Cross-frontier movements of flasks require that calibrations and measurement techniques be internationally acceptable. All FLITE instrumentation and calibration standards are traceable to national standards. The Winfrith pressure calibration laboratory is one of the best in the UK outside the National Physical Laboratory.

Hardware and Software.

FLITE consists essentially of pressure transducers and temperature sensors linked to a microprocessor. Software and a high precision analogue to digital converter have been developed together and incorporate sophisticated signal noise reducing techniques.

The FLITE system is subjected to a continuous self-checking programme comparing measurements with preset parameters, giving warning of any result which lies outside the expected range. Since all the readings are compared with precalculated figures the system certifies at the end of a test all measurements recorded are satisfactory.

The transducers available allow measurements over a wide range of pressures extending from 2 bar to 700 bar. The software can be customised for measurements of virtually any quantity in terms of temperature and pressure and is menu selectable.

A print out of the test results is provided along with flask details and transducer status as follows:

Flask Leak Test

Measuring Unit Serial Number

Flask Details-Type, Serial No, Date etc.

Test Point	Delta P	Cal-d Vol	Standardised Leak Rate
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Transducer Status Summary for 8 channels.

This becomes a QA document for the tests carried out once it is signed by the appropriate foreman.

Pressure testing of Flasks

Two channels are installed in the standard unit to allow pressure testing of flasks to be carried out. The print out of the results include all flask details etc. followed by :

Pressure Test

Pressure at Start of Test xxx Bar

Duration of Test x Minutes

Pressure at end of Test xxx Bar

This is followed by the transducer status statement.

This becomes a QA document for the tests carried out once it is signed by the appropriate foreman.

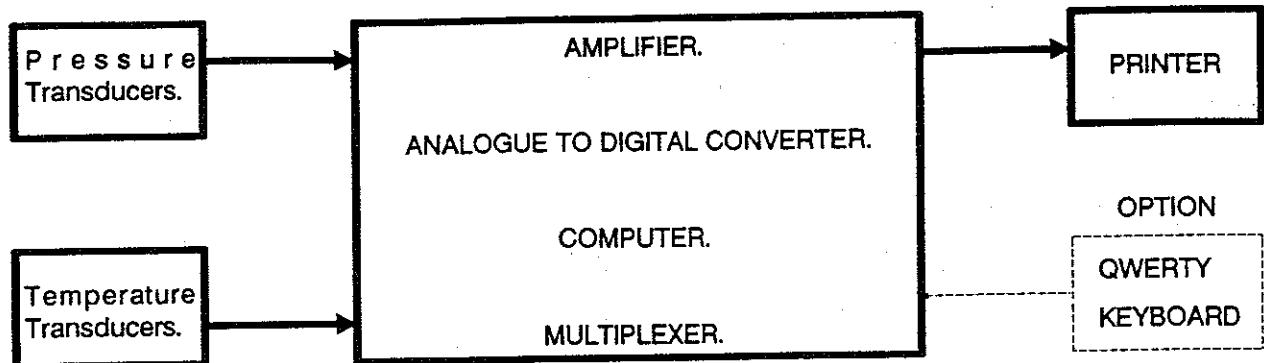
The unit can cater for up to 64 channels of pressure and temperature measurement.

During calibration Winfrith may be able to provide a duplicate system.

Typical price for a standard system is £29750 at 1989 prices, quotations will be provided for specific systems on request.

AEA Technology

Block Diagram of FLITE



Specifications.

Average Test Time	: 30 Minutes (AECP Draft 1068)
Accuracy	: +/- 10% on a 1×10^{-5} bar ml/s standardised leak rate at a 2 bar A test pressure.
Sensitivity	: 1×10^{-8} bar ml/s at a 2 bar A test pressure.
Measurement Range	: 1×10^{-6} bar ml/s at a 2 bar A test pressure.
Dimensions	: 380 x 380 x 170mm
Weight	: 14Kg
Power	: 240V 50Hz 2A or 110V 60Hz 4A

For further information contact :

AEA Technology
Attn : Mr J G Burland
Room 107 Building B47
Winfirth Technology Centre,
Dorchester,
Dorset. DT2 8DH
UK

Telephone (0305) 251888 Ext 3360
Facsimile (0305) 202984

COMMISSION OF THE EUROPEAN COMMUNITIES
WORKING GROUP ON HOT CELL AND REMOTE HANDLING TECHNOLOGY
1989 PLENARY MEETING - KARLSRUHE

INTERVENTION IN HIGHLY CONTAMINATED α - β - γ HOT CELL
AND REEQUIPMENT

A.DANIELS - E.VANHOOF - T.VAN RANSBEECK - J.VAN DE VELDE

Poster Session

APPROVED BY


A.C. DEMILDIT

LHMA

TEC/39.X5562/20/AD/EVH/TVR/JVDV
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FIG. 1. SITUATION HOT CELLS M1-M2

FIG. 2. EVACUATION OF WASTE

FIG. 3. DECONTAMINATION

FIG. 4. ADAPTATION AND REPAIR

TABLE I. SUMMARY

TABLE II. WORKTIME

TABLE III. RECEIVED DOSES

TABLE IV. WASTE ARISINGS

1. INTRODUCTION

SINCE MAY 1985 A NEW HOT CELL FACILITY, CONSISTING OF TWO HEAVY CONCRETE-SHIELDED CELLS M1 AND M2, IS IN OPERATION AT THE SCK/CEN LABORATORY L.H.M.A. (1).

AS PLANNED, THE HOT CELL M2 HAS BEEN USED DURING THESE YEARS FOR DESTRUCTIVE WORK ON IRRADIATED FUEL PINS AND ACTIVATED MATERIALS.

ALL THESE OPERATIONS CAUSED HIGHLY β - γ AND PLUTONIUM CONTAMINATED WASTE AND A SPREADED CONTAMINATION ON EQUIPMENT, FLOOR AND WALLS.

2. AIM OF THE INTERVENTION

THE AIM OF THE INTERVENTION IN THE HOT CELL WAS TWOFOLD :

- A. THE INSTALLATION OF A NEW SAWING-MACHINE FOR SAWBLADE DIAMETERS UP TO 300 MM IN THE FRAME OF THE PAHR PROGRAMMES;
- B. ADAPTATION AND REPAIR OF THE EXISTING EQUIPMENT.

3. PROCEDURE

3.1. PREDECONTAMINATION

THIS WORK WAS PERFORMED BY MEANS OF THE MASTER SLAVE MANIPULATOR AND CONSISTED OF :

- THE EVACUATION OF WASTE AND OTHER RADIOACTIVE SOURCES;
- THE DISMANTLING, DECONTAMINATION AND PACKING OF THE OLD CUTTING MACHINE;
- THE DECONTAMINATION OF THE PLACES ATTAINABLE BY THE MASTER SLAVE MANIPULATORS;
- THE RENEWAL OF THE HEPA-AIR-FILTERS AND EVACUATION OF THE NEWLY PRODUCED WASTE IN POLYETHYLENE CONTAINERS (TYPE LA CALHÈNE).

3.2. INTERVENTION IN HOT CELL M2

3.2.1. PREPARATION (FIG. 1 - FIG. 2)

CONSTRUCTION AND INSTALLATION OF INTERVENTION TENTS AND SCAFFOLD.

3.2.2. INTERVENTION

- EVACUATION OF SPECIAL WASTE (400 L - DRUM) - FIG. 2
PHOTOGRAPH No. 1 - 2 - 3
- DECONTAMINATION OF WALLS AND FLOOR - FIG. 3
PHOTOGRAPH No. 4 - 5
- REPAIR OF THE DEFECT BRIDGE CRANE AND EQUIPMENT - FIG. 4
PHOTOGRAPH No. 6 - 7 - 8 - 9
- INSTALLATION OF THE NEW SAWING-MACHINE - FIG. 4
PHOTOGRAPH No. 10 - 11 - 12
- CLEARING AWAY : EVACUATION OF WASTE AND INTERVENTION MATERIAL.

4. RESULTS

4.1. NUMBER OF INTERVENTIONS (TABLE I)

27 DIFFERENT PERSONS FULFILLED 33 INTERVENTIONS IN PRESSURIZED SUITS WITH AN AVERAGE DURATION OF 2 HOURS PER INTERVENTION.

4.2. WORKTIME DURATION (TABLES I AND II)

PREDECONTAMINATION : ONE CELL OPERATOR FOR SIX MONTHS = 137 MAN-DAYS

INTERVENTION : DURING 4 MONTHS PERMANENT AND TEMPORARY PERSONNEL PERFORMED 202 MAN-DAYS.

4.3. RECEIVED DOSES (TABLE III)

THE CUMULATED DOSES FOR 27 PERSONS WAS 88.50 mSv FOR 12 WEEKS WITH AN AVERAGE OF 3.26 mSv AND A MAXIMUM DOSE OF 8.41 mSv.

OTHER DOSES FOR SKIN AND FINGERS ARE GIVEN IN TABLE III.

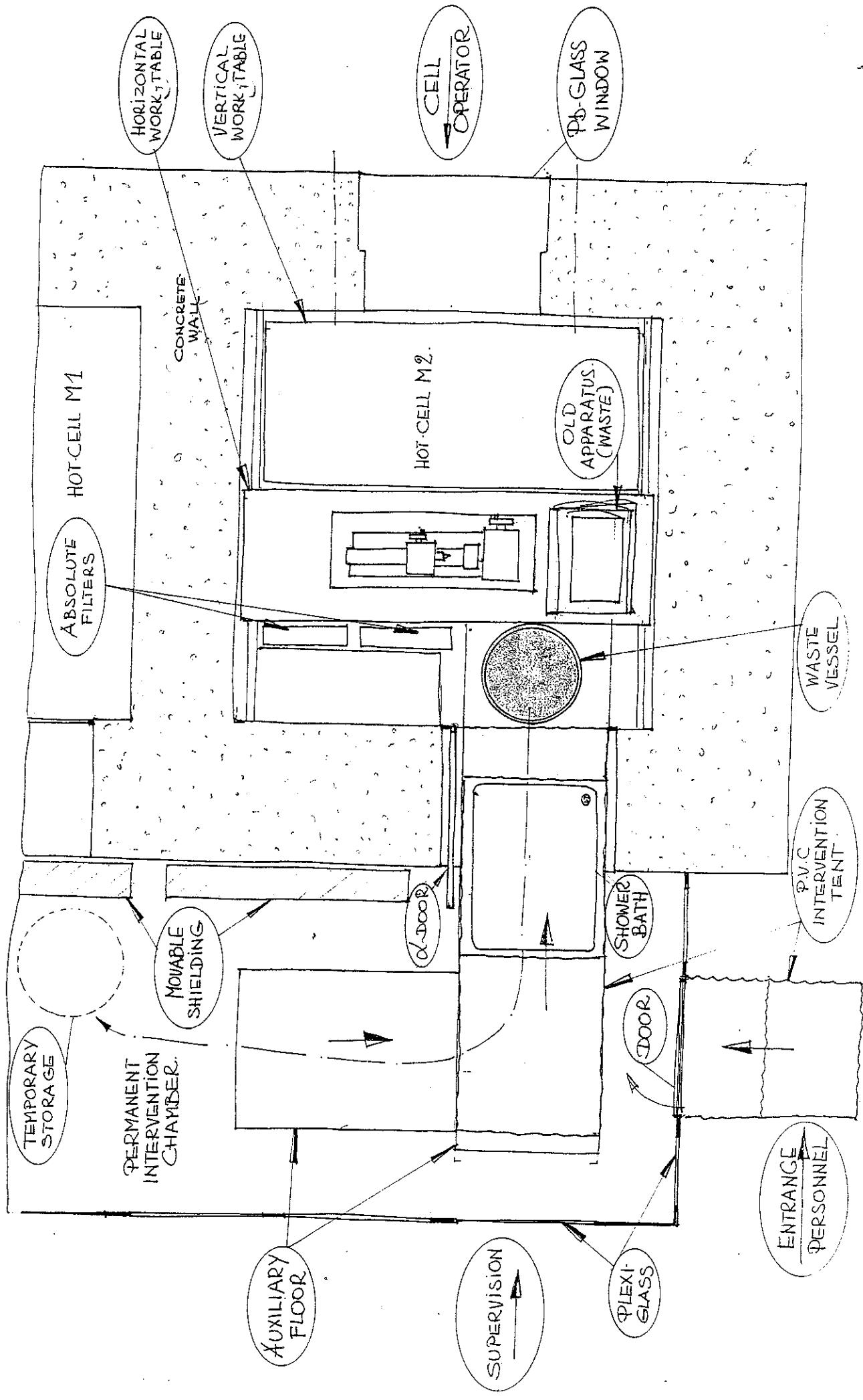
4.4. WASTE ARISING (TABLE IV)

THE PRIMARY WASTE WAS EVACUATED IN EIGHT 50 L POLYETHYLENE CONTAINERS (TYPE LA CALHÈNE CTPE 270-70) AND ONE 400 L DRUM.

THE SECONDARY WASTE HAD A VOLUME OF FORTY 30 L CANS AND TWO 200 L DRUMS.

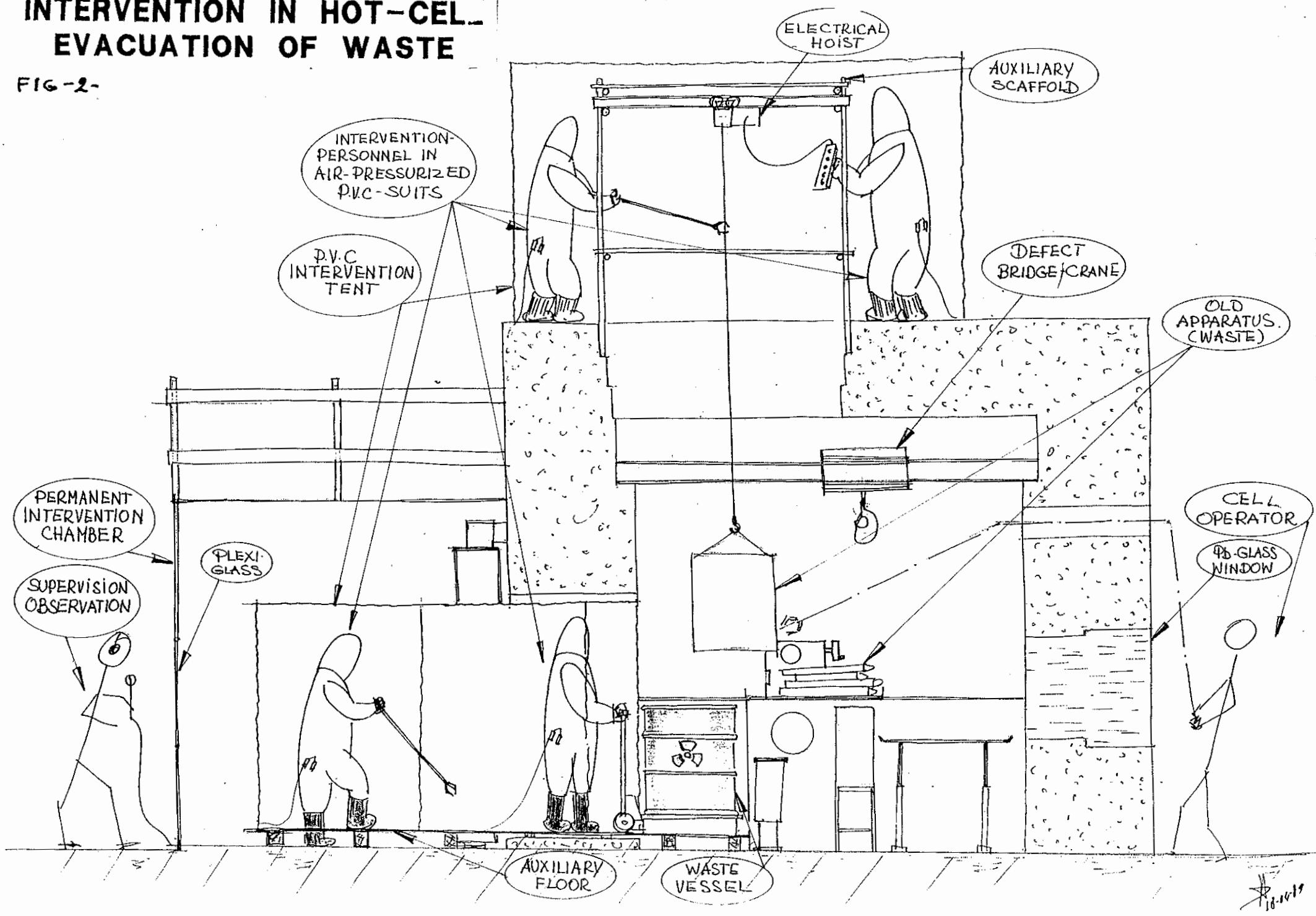
INTERVENTION IN HOT-CELL SCHEMATIC VIEW

Fig - 4 -



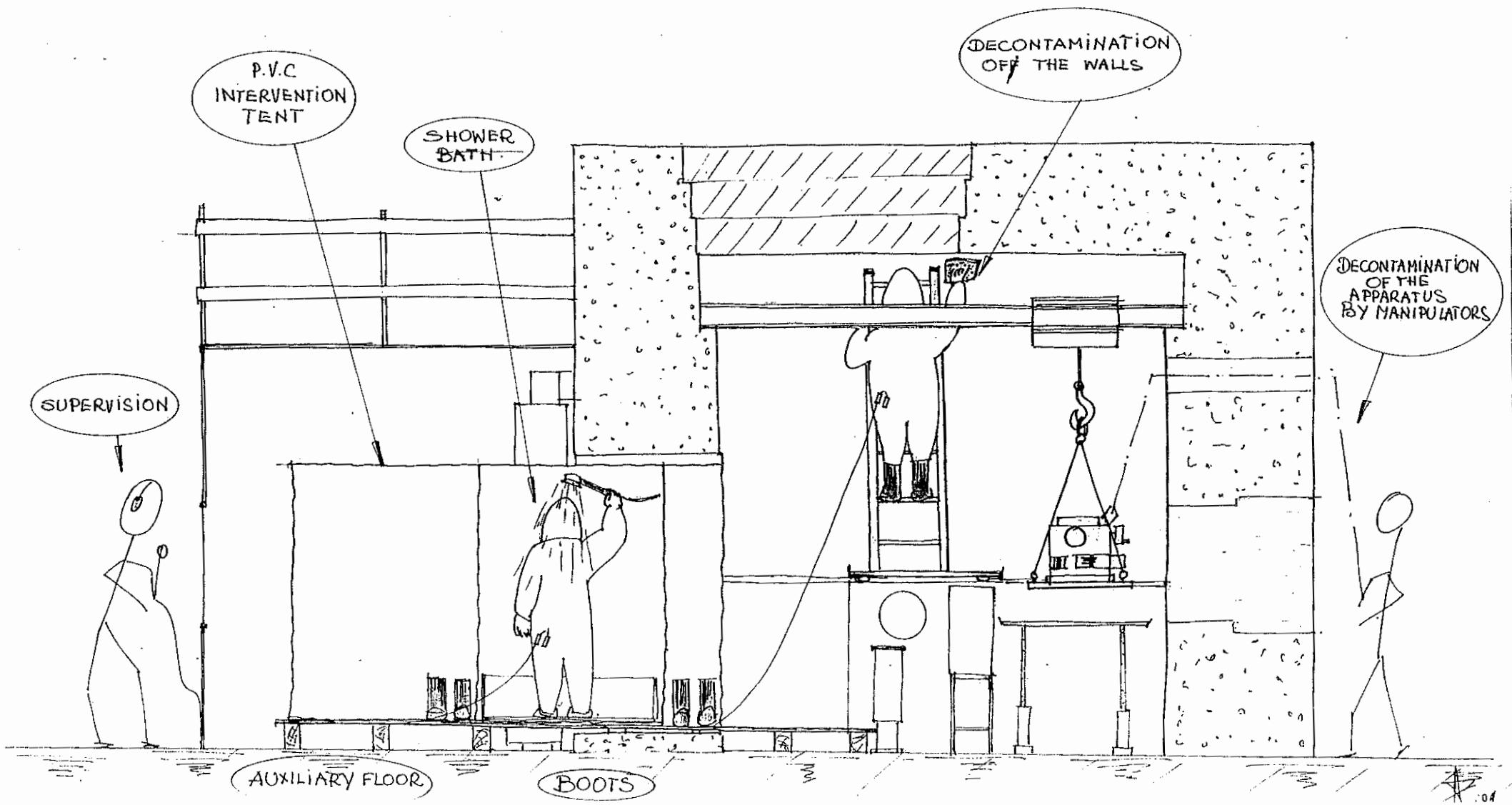
INTERVENTION IN HOT-CELL EVACUATION OF WASTE

FIG-2-



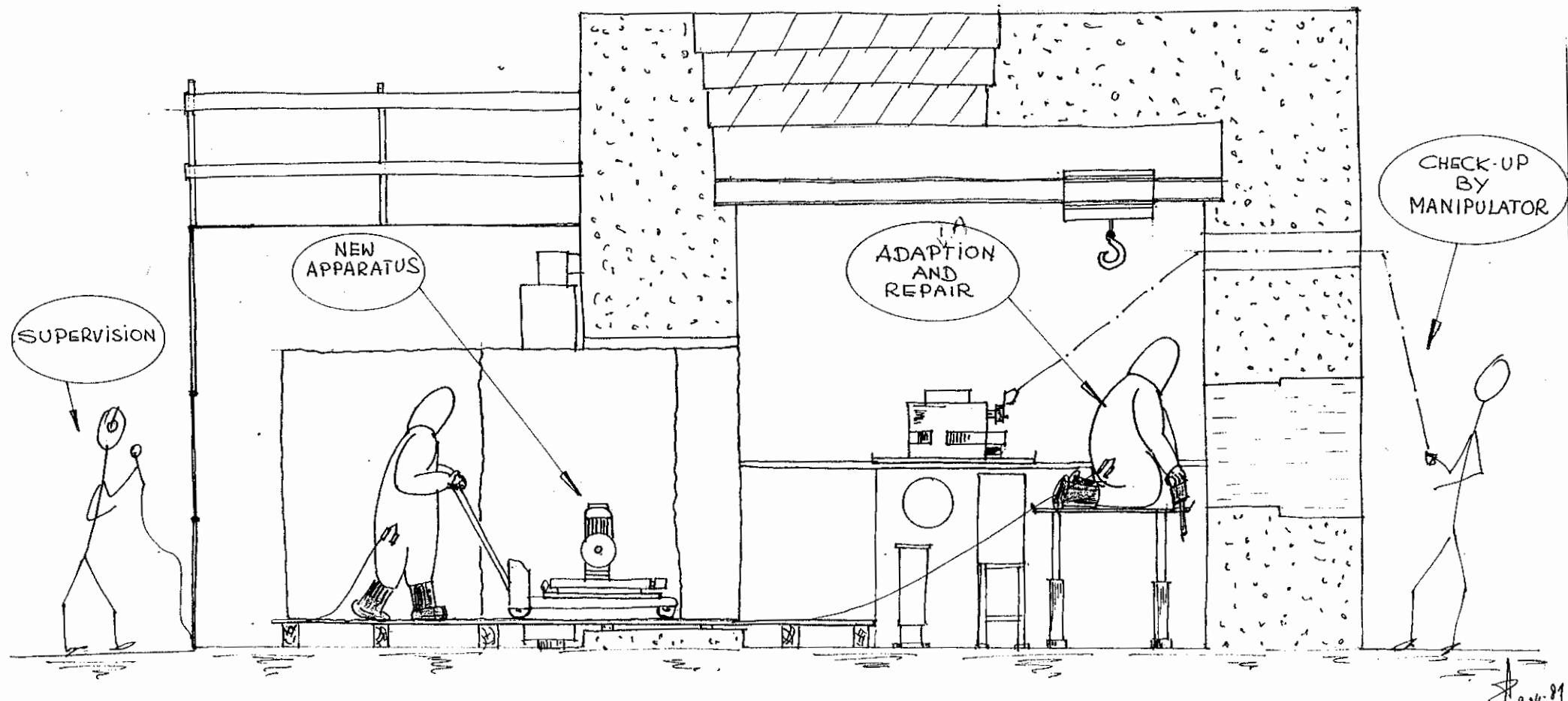
INTERVENTION IN HOT-CELL DECONTAMINATION

FIG.-3-



INTERVENTION IN HOT-CELL RE-EQUIPEMENT

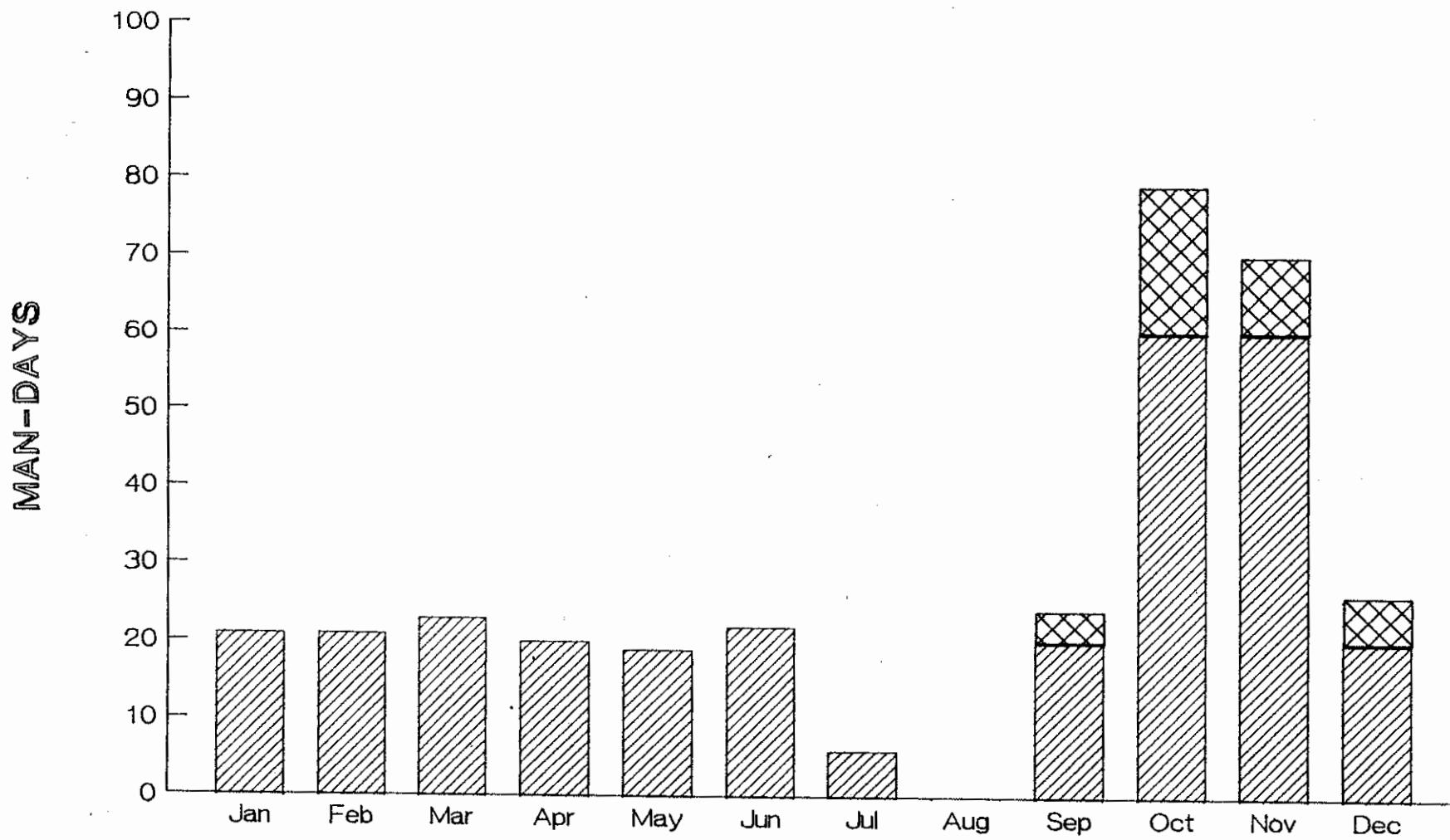
FIG-4-



PERIOD	RADIATION LEVEL		RESIDUAL CONTAMINATION MEASURED BY :
	AFTER EVACUATION	AVERAGE : 20 mSv/h MAXIMUM : 400 mSv/h	
JAN	EVACUATION OF WASTE AND OTHER RADIATION SOURCES DISMANTLING DECONTAMINATION AND PACKING OF THE OLD APPARATUS		SMEAR TEST(1 dm ²) AVERAGE : 0.23 mSv/h MAXIMUM : 1 mSv/h
JUL	DECONTAMINATION OF THE ATTAINABLE PLACES BY MASTER SLAVE MANIPULATORS RENEWAL OF THE HEPA-FILTERS AND EVACUATION OF THE NEWLY PRODUCED WASTE		LF DOSIMETER AVERAGE : 5.10 mSv/h MAXIMUM : 6.87 mSv/h
SEP	INTERVENTION : DECONTAMINATION AND REEQUIPMENT	PREPARATION -CONSTRUCTION AND INSTALLATION OF THE INTERVENTION TENTS AND SCAFFOLD INTERVENTION -EVACUATION OF WASTE -DECONTAMINATION OF WALLS AND FLOOR -REPAIR OF THE DEFECT BRIDGE CRANE -REEQUIPMENT OF THE APPARATUS AND WORKTABLES -INSTALLATION OF NEW APPARATUS CLEARING AWAY -EVACUATION OF WASTE -DEMOLISHING AND REMOVAL OF THE INTERVENTION MATERIAL	3.3 INTERVENTIONS OF 2 PERSONS 27 DIFFERENT PERSONS AVER. DOSE IN mSv 10 PERS : 1 INTERV. 9 PERS : 2 INTERV. 4 PERS : 3 INTERV. 2 PERS : 5 INTERV. 1 PERS : 6 INTERV. 1 PERS : 11 INTERV.
DEC		DOSE PARTITION FOR 27 PERSONS BODY DOSE NUMBER OF FINGER DOSE NUMBER OF PERSONS mSv PERSONS mSv PERSONS	< 1 2 < 10 10 1 - 2 8 10 - 20 8 2 - 5 12 20 - 50 7 5 - 10 5 50 - 100 2

TABLE I.

INTERVENTION IN HOT CELL M2 WORKTIME IN MAN-DAYS



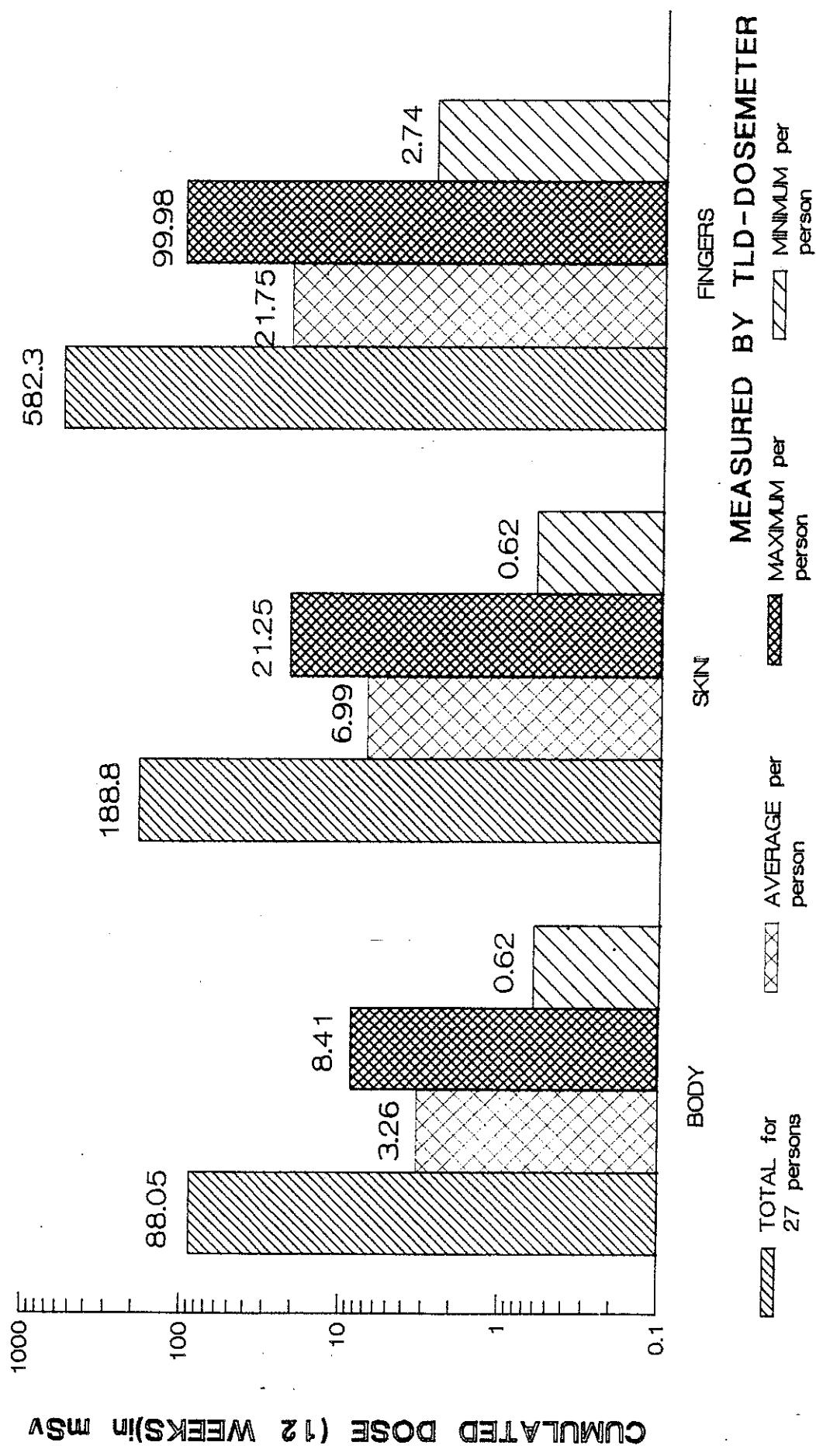
1988

PERMANENT
personnel

TEMPORARY
personnel

TABLE II.

DOSES RECEIVED DURING THE INTERVENTION IN THE HOT CELL M2



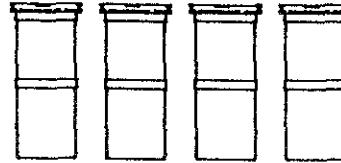
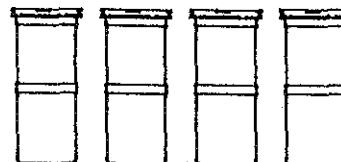
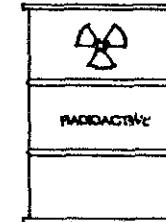
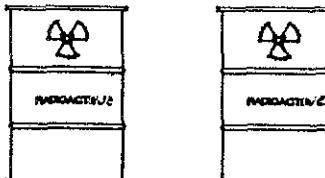
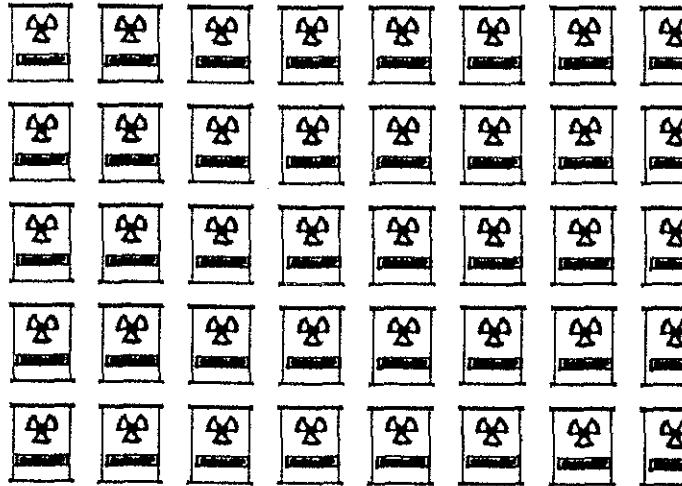
WASTE ARISINGS				mGy
PREDECONTAMINATION				
<u>EVACUATED</u>	DISCARDED APPARATUS ABSOLUTE FILTERS CONTAMINATED RAGS	 		10
	8 x 50 l 1 x 400 l			>10⁴
INTERVENTION				1
<u>EVACUATED</u>	CONTAMINATED DEBRIS CONTAMINATED INTERVENTION SUITS CONTAMINATED INTERVENTION TENTS		SECONDARY	
	2 x 200 l 40 x 30 l			30

TABLE IV.

RH/EA

DEPARTEMENT D'ETUDES DES COMBUSTIBLES
A BASE DE PLUTONIUM ET D'URANIUM

SERVICE DES ELEMENTS COMBUSTIBLES
ET DES LABORATOIRES DE HAUTE ACTIVITE

TELEMANIPULATEUR TELECOMMANDE MAITRE ESCLAVE 500

R. HUILLY

Communication présentée en "poster session" lors de la réunion plénière 1989 du Groupe de Travail "Laboratoire chauds - Télémanipulation" de la Commission des Communautés Européennes les 27 et 28 Septembre 1989 à KARLSRUHE.

TELEMANIPULATEUR TELECOMMANDE MAITRE ESCLAVE 500

R. HUILERY

Le CEA réalise actuellement à CADARACHE une installation baptisée STAR comportant une chaîne de cellules chaudes. Dans ces dernières, il est prévu de réaliser, à cadence élevée, des manipulations d'objets dont la masse sera comprise entre 15 et 20 Kg.

Ce travail se situe à la limite des possibilités des télémanipulateurs maître-esclaves MT 200 ou A 100, mais aussi à la limite tolérable des efforts musculaires développés par les agents sur les bras "Maître" pour exécuter ces opérations en cellule.

Il est donc apparu nécessaire d'envisager l'usage permanent d'un manipulateur lourd télécommandé.

Les matériels de ce type présents dans le commerce sont en général commandés par un clavier constitué de contacteurs permettant d'animer individuellement les actionneurs du bras manipulateur situé en cellule ce qui conduit à des manipulations lentes et fastidieuses.

Les concepteurs de ce projet ont donc opté pour le développement d'un télémanipulateur lourd équipé d'un dispositif de commande plus instinctif et plus rapide que celui des machines actuelles et ayant une dextérité d'exécution très élevée.

Cet ensemble maître-esclave présente les caractéristiques suivantes :

Bras esclave

- capacité de charge toutes positions : 500 N
- longueur du bras déployé : 1,30 m
- degrés de liberté : 6

θ_1 = lacet	amplitude $\pm 175^\circ$	vitesse maxi : 4 tr/mn
θ_2 = épaule	amplitude $\pm 112^\circ$	vitesse maxi : 1,7 tr/mn
θ_3 = coude	amplitude $+105^\circ, -15^\circ$	vitesse maxi : 1,7 tr/mn
θ_4 = avant bras	amplitude $\pm 175^\circ$	vitesse maxi : 8,6 tr/mn
θ_5 = inclinaison pince	amplitude $\pm 100^\circ$	vitesse maxi : 10,7 tr/mn
θ_6 = rotation pince	amplitude infinie	vitesse maxi : 15 tr/mn

- pince à mors parallèles
déconnectable automatiquement
ouverture maximum : 150 mm
effort de serrage : 900 N
doigts interchangeables
- motorisation assurée par des moteurs à courant continu à balais ,associés à des génératrices tachymétriques et à des freins électromagnétiques
- le contrôle de l'exécution des mouvements est effectué par des résolveurs placés sur chaque articulation
- ses déplacements en cellule sont assurés par un support télescopique mobile dans deux directions
- ses dimensions lui permettent d'être introduit en cellule par un orifice de 250 mm.

Bras maître

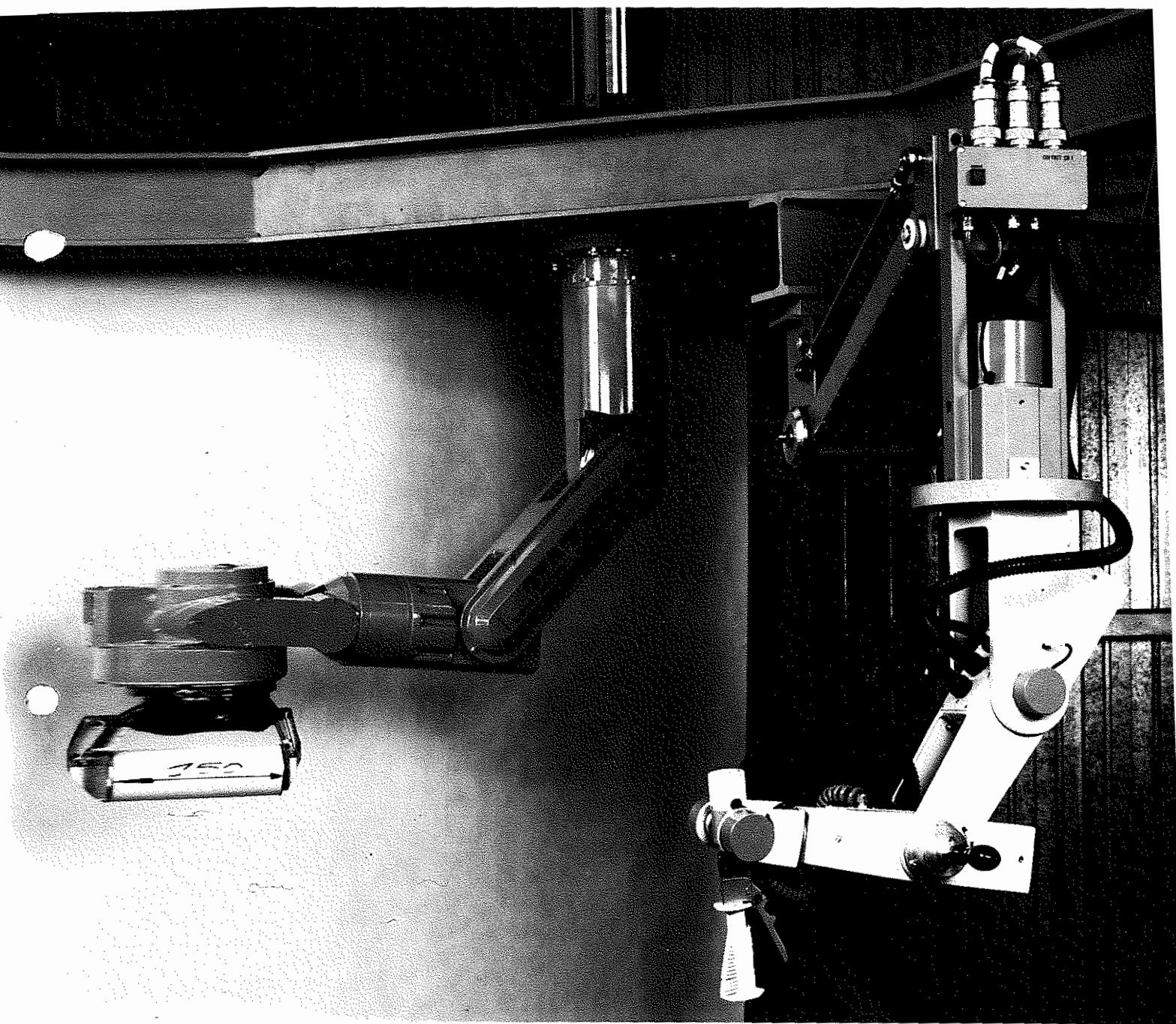
- Placé devant la fenêtre d'observation, il est d'une manipulation aisée grâce à sa taille réduite et à l'équilibrage des différentes parties mobiles
- Chaque axe d'articulation comprend un capteur potentiométrique et un frein de maintien électromagnétique à manque de courant.

Sa conception permet à l'opérateur, par les mouvements de sa main, d'indiquer au bras esclave situé en cellule chaude les mouvements qu'il souhaite exécuter. Le bras esclave reproduit fidèlement ces mouvements avec un léger retard qui est fonction de la rapidité de l'opérateur.

La surveillance du bras esclave durant ses évolutions doit être permanente car l'opérateur ne reçoit pas d'information sur les efforts qu'effectue le bras esclave, cependant, des dispositifs de limitation d'effort sont disposés sur l'alimentation de chacun des actionneurs.

Les essais du prototype de cette machine sont prévus vers mi 1989.

TELEMANIPULATEUR TELECOMMANDE MAITRE ESCLAVE 500



CEA - CEN.FAR
IRDI
DERDCA/DCAEA
SERVICE D'ETUDES ANALYTIQUES
LABORATOIRE DE METROLOGIE
DES MATIERES NUCLEAIRES

COMMISSION OF EUROPEAN COMMUNITIES
WORKING GROUP ON HOT CELL AND REMOTE HANDLING TECHNOLOGY
1989 PLENARY MEETING - KARLSRUHE (RFA)

SCELLEMENT D'AMPOULES DE VERRE PAR FAISCEAU LASER EN BOITE
A GANTS EN VUE DE CONDITIONNER DES ECHANTILLONS ANALYTIQUES

C. GUICHARD - P. DELORME

Commissariat à l'Energie Atomique IRDI/DCAEA/SEA/LAMMAM
BP n°6 - 92265 Fontenay aux Roses Cedex (FRANCE)

RESUME

Le but est de conserver des aliquotes de solutions de transuraniens et des échantillons représentatifs de lots d'oxyde de plutonium, pour des analyses différées.

Le faisceau d'un laser à CO₂ de 100 w de puissance est introduit dans une boîte à gants, par l'intermédiaire d'une lentille en sélénium de zinc. Il est focalisé sur l'extrémité en forme de tubulure d'une ampoule de verre. Celle-ci est rendue solidaire d'un réceptacle qui est animé d'un mouvement de rotation, ce qui permet d'obtenir une fusion homogène du verre.

Par translation de ce réceptacle sur un rail, l'extrémité soudée est déplacée dans l'axe du faisceau laser vers une position de "recuit". Le diamètre de l'impact est ainsi augmenté. On diminue alors la puissance du laser. Cette dernière opération atténue les contraintes formées lors de la soudure.

Par sécurité, le trajet du faisceau est capoté et un puits de graphite absorbe ce faisceau lorsqu'il n'est pas utilisé.

Un ensemble vidéo permet de suivre l'opération de scellement sans risque.

INTRODUCTION

Dans le groupe CEA, le Laboratoire de Métrologie des Matières Nucléaires (LAMMAM) du Service d'Etudes Analytiques (SEA), a la charge de préparer des solutions de référence d'uranium et de transuraniens ainsi que de certifier des lots d'oxyde de plutonium /1/.

Ces matériaux sont fournis :

- d'une part, aux laboratoires du groupe qui en font la demande. Ils sont alors destinés à étalonner les méthodes d'analyses.
- d'autre part, au Contrôle National qui, soucieux de la qualité des déterminations sur lesquelles reposent en partie les bilans, demande aux exploitants d'analyser des solutions inconnues ou des échantillons d'oxyde de plutonium.

Dans ce dernier cas, ces matériaux sont distribués dans le cadre du programme: "Evaluations de la Qualité des Résultats d'Analyse dans les Installations Nucléaires" (EQRAIN), par la CETAMA /2/, à l'ensemble des laboratoires du Groupe CEA et à quelques laboratoires de la Communauté.

Pour répondre à ces préoccupations, le LAMMAM s'est équipé d'une installation de conditionnement d'échantillons en ampoules de verre scellées que nous nous proposons de décrire.

1 - DESCRIPTION DE L'INSTALLATION

Elle est visible sur la figure n°1 et comprend :

- trois boîtes à gants dans lesquelles sont effectués : la préparation, les pesées des échantillons actifs et le scellement des ampoules de verre,
- une armoire métallique dans laquelle sont scellées les ampoules d'uranium naturel,

- un laser à CO₂ PICOUT d'une puissance pouvant varier de 20 à 150 watts, qui émet un faisceau de lumière cohérente à 10,6 microns,
- un système de dérivation du faisceau laser, sous la forme d'un miroir pivotant,
- un puits de graphite qui bascule sur le trajet du faisceau lorsque l'opération de scellement est terminée,
- un banc de purification JACOMEX qui permet de travailler dans les boîtes à gants sous atmosphère inerte, en assurant jusqu'à 14 renouvellements par heure.

2 - REALISATION DU SCELLEMENT

Le chemin parcouru par le faisceau laser est schématisé sur la figure n°2.

Lorsque le système de dérivation est hors circuit, il pénètre dans la boîte à gants à travers un collimateur que l'on peut voir sur la figure n°3. C'est une lentille en sélénium de zinc qui focalise le faisceau sur la partie du tube de verre à souder et assure également l'étanchéité de l'enceinte. Elle est refroidie par une circulation d'air, en cas d'utilisation intense.

Si le faisceau rencontre le miroir, il est dévié à 90° et pénètre dans l'armoire métallique.

Dans les deux cas, il frappe l'extrémité de l'ampoule à sceller. Celle-ci est placée sur le réceptacle représenté sur la figure n°4. Un moteur CROUZET muni d'un réducteur, l'entraîne dans un mouvement de rotation à vitesse constante, autour de l'axe de la tubulure à souder.

L'ensemble réceptacle et moteur repose sur deux rails qui lui permettent de se déplacer, d'une position de "soudure"

à une position de "recuit". Au cours de cette dernière phase de l'opération, le faisceau étant défocalisé, la surface chauffée augmente; on diminue également la puissance du laser. Ceci permet d'atténuer les tensions créées par la soudure.

Pour des raisons de sécurité, le trajet du faisceau en boîte à gants est capoté et l'opération est suivie à l'aide d'un système vidéo. On distingue sur la droite de la figure n°5, la caméra qui reçoit l'image transmise par un miroir de renvoi.

3 - CONDITIONS D'UTILISATION DU FAISCEAU

La durée du scellement est d'une minute pendant laquelle la puissance du laser est fixée entre 50 et 80 watts selon le diamètre du tube de verre à souder.

Le diamètre de l'impact est de 4 à 5 mm. Il est de 12 à 14 mm en position de recuit, pour une puissance utilisée de 20 à 40 watts. La durée est alors de 2 à 5 minutes.

4 - TYPES D'AMPOULES UTILISES

Au premier plan de la figure n°6 se trouvent les deux types de conteneurs destinés à stocker des échantillons de plutonium, sous forme d'oxyde ou de métal.

Dans le cas de l'oxyde, les ampoules sont prévues pour pouvoir être brisées dans le dissolvEUR réservé à cet effet par chaque utilisateur. Après analyse, celui-ci sera en mesure de donner à l'organisme demandeur la masse de plutonium contenu dans chacune des ampoules.

On distingue à l'arrière-plan de la même figure, le type de conteneur utilisé pour conditionner les solutions du circuit "EQRAIN".

La double tubulure permet de rincer convenablement, dans le cas où l'on veut utiliser la totalité du contenu. Un autre avantage est que la partie du verre en fusion est suffisamment éloignée de la solution pour écarter tout risque d'évaporation; ceci permet de garantir la concentration de la solution.

5 - ECHANTILLONNAGE DE L'OXYDE DE PLUTONIUM

L'oxyde est calciné à 950°C pendant 2 heures dans un four tubulaire ADAMEL FP 15. Celui-ci est visible sur la figure n°7.

Au cours de la période de refroidissement, la nacelle de platine qui contient 10 à 20 g du matériau à échantillonner est sortie du four à 150°C, placée dans une boîte métallique et transférée dans l'installation de conditionnement.

Après une nuit de refroidissement sous argon sec, le lot d'oxyde de plutonium est homogénéisé pendant une demi-heure.

L'homogénéiseur représenté sur la figure n°8 est composé d'un tube de verre coudé en forme de V, entraîné à faible vitesse dans un mouvement rotatif par un moteur CROUZET.

Des fractions d'oxyde de plutonium comprises entre 0,5 et 1 g sont ensuite pesées à $\pm 0,1$ mg, dans des ampoules de verre préalablement tarées sur une balance METTLER A 200. On distingue ce poste de travail sur la figure n°9.

Pour s'affranchir des phénomènes d'électricité statique que l'on rencontre en atmosphère sèche, chaque ampoule est pesée dans un support métallique. Entre deux pesées ce support est posé sur le fond de la boîte à gants, lui-même en acier inoxydable et relié à la prise de terre du bâtiment.

CONCLUSION

Dans le but de conditionner des aliquotes de solutions de référence d'uranium et de transuraniens, ainsi que des échantillons représentatifs de lots d'oxyde de plutonium, une installation de scellement d'ampoules de verre par faisceau laser a été réalisée au Service d'Etudes Analytiques.

L'utilisation d'un faisceau laser, pour sceller les conteneurs de verre présente l'avantage de ne pas modifier l'atmosphère de l'enceinte de confinement. Ceci est particulièrement important, lorsque l'on se propose de conserver des échantillons représentatifs de lots d'oxyde de plutonium, produit particulièrement hygroscopique, en vue d'analyses différées.

Les échantillons peuvent ensuite être distribués à différents laboratoires sans crainte d'évolution pendant le stockage.

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 9th annual ESARDA Symposium
 Londres (1987)
- / 2 / C. Houin
 9th annual ESARDA Symposium
 Londres (1987)
-

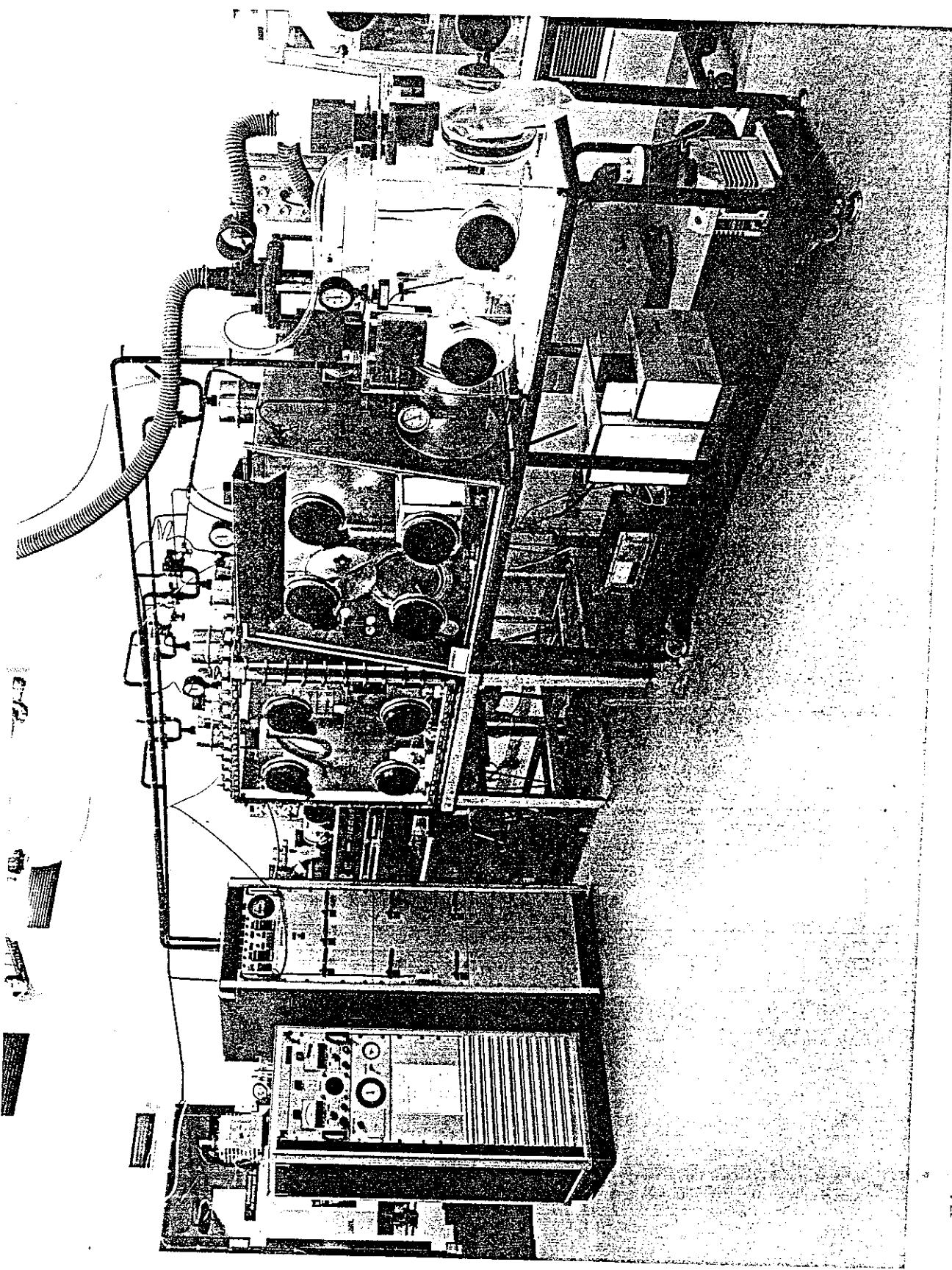
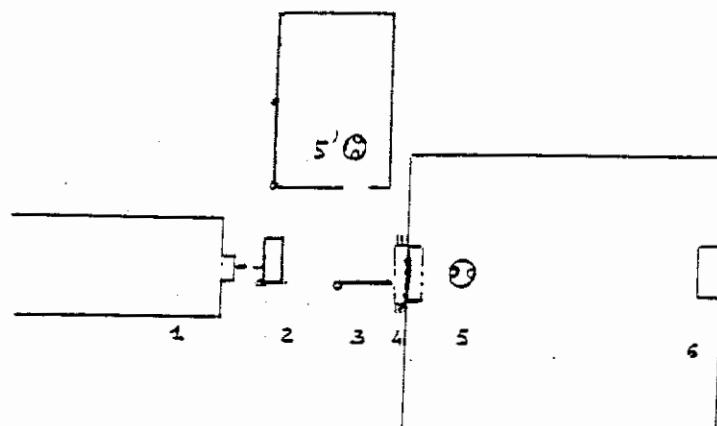
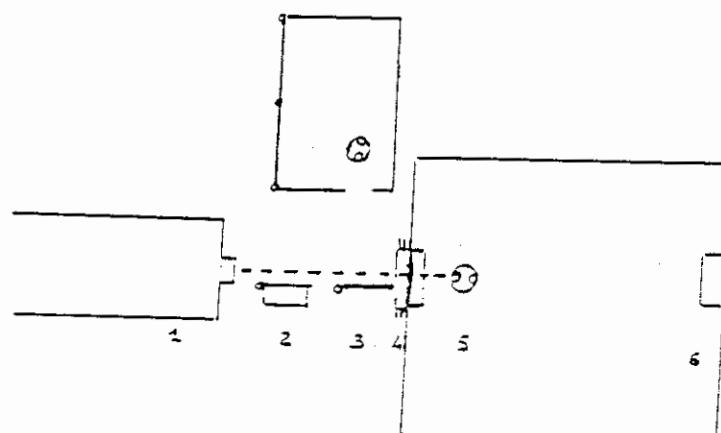


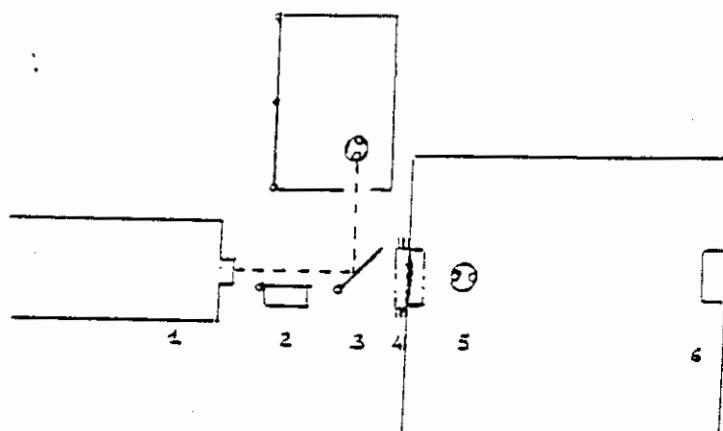
Figure 1 - Installation de conditionnement d'échantillons en ampoules de verre scellées par faisceau laser.



- Position de sécurité



- Tir du laser dans la boîte à gants



- Tir du laser dans l'armoire

- | | |
|------------------------------------|-----------------------------|
| 1 - Laser à CO ₂ PICOUT | 4 - Lentille Zn Se |
| 2 - Protection graphite | 5 et 5' - Ampoules de verre |
| 3 - Miroir pivotant | 6 - Protection graphite |

Figure 2 - Trajets du faisceau laser

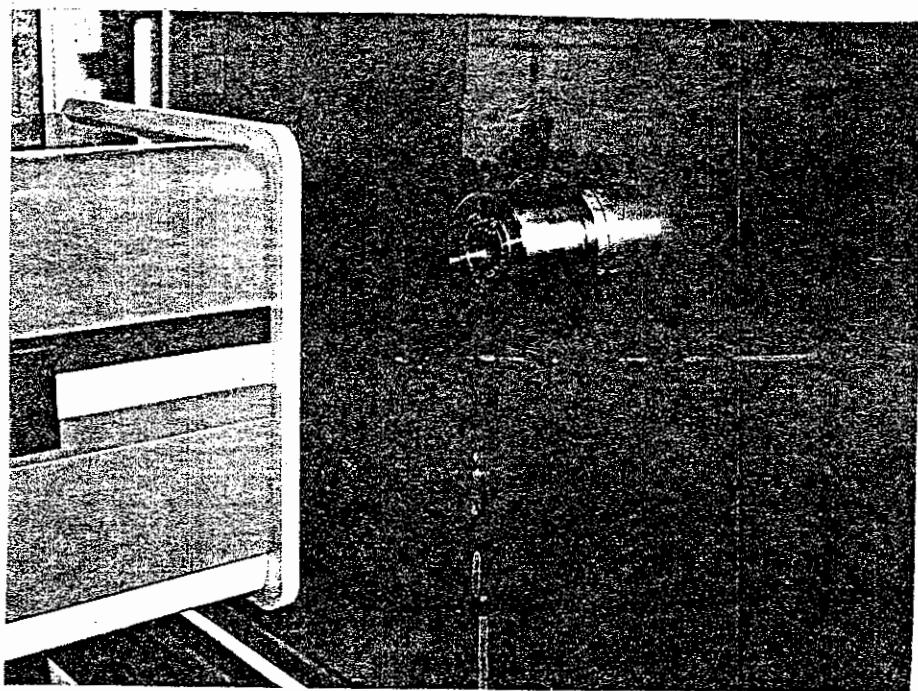


Figure 3 - Collimateur fixé sur la paroi de la boîte à gants.

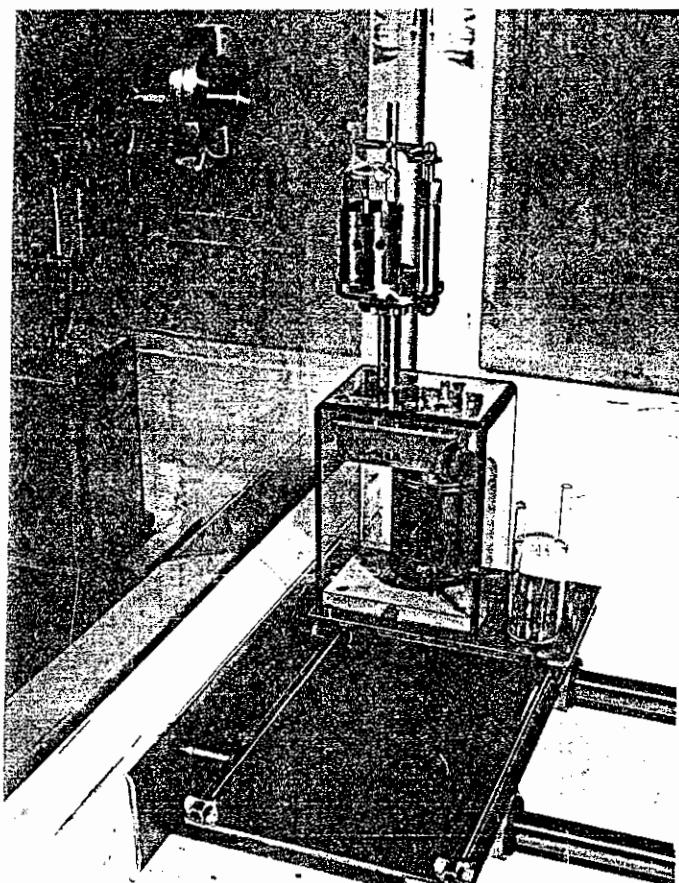


Figure 4 - Ampoules en position de scellement sur le réceptacle mobile.

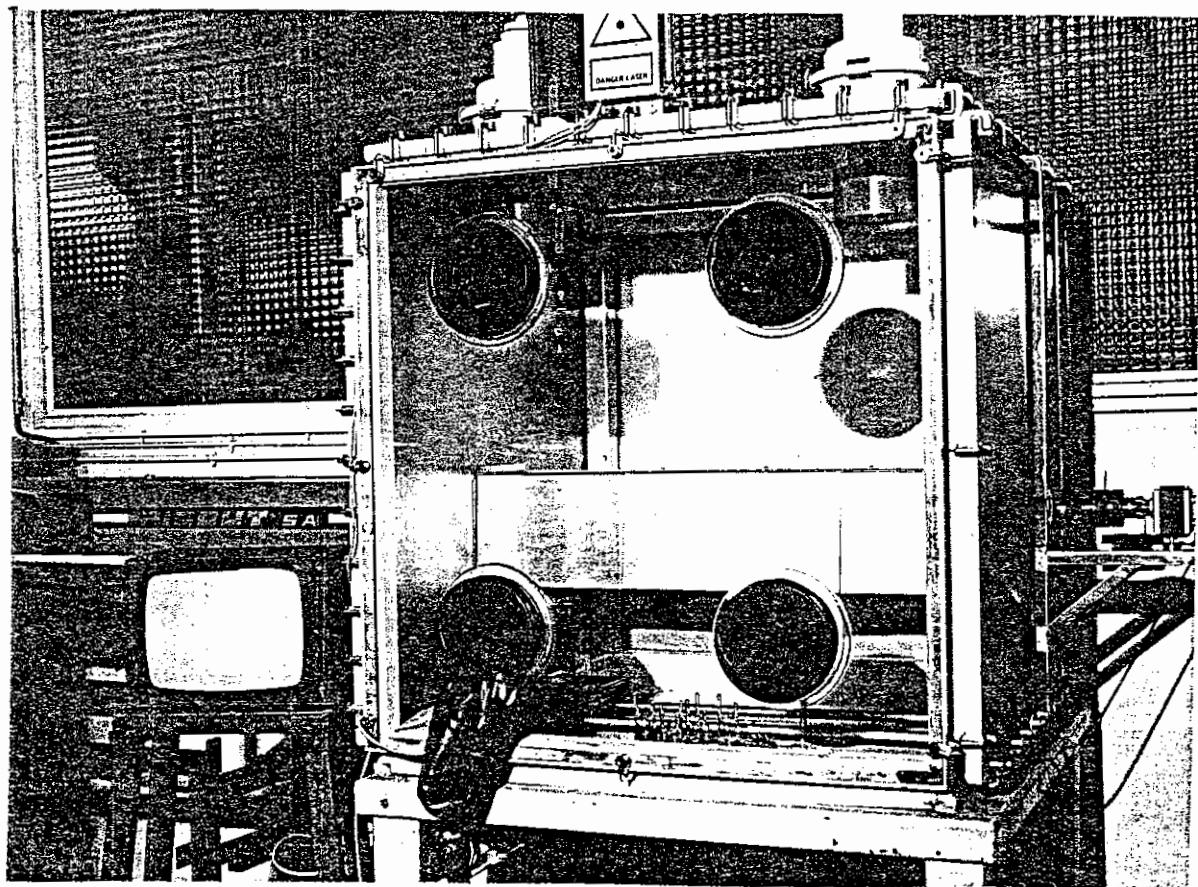


Figure 5 - Système vidéo qui permet de suivre l'opération de scellement.

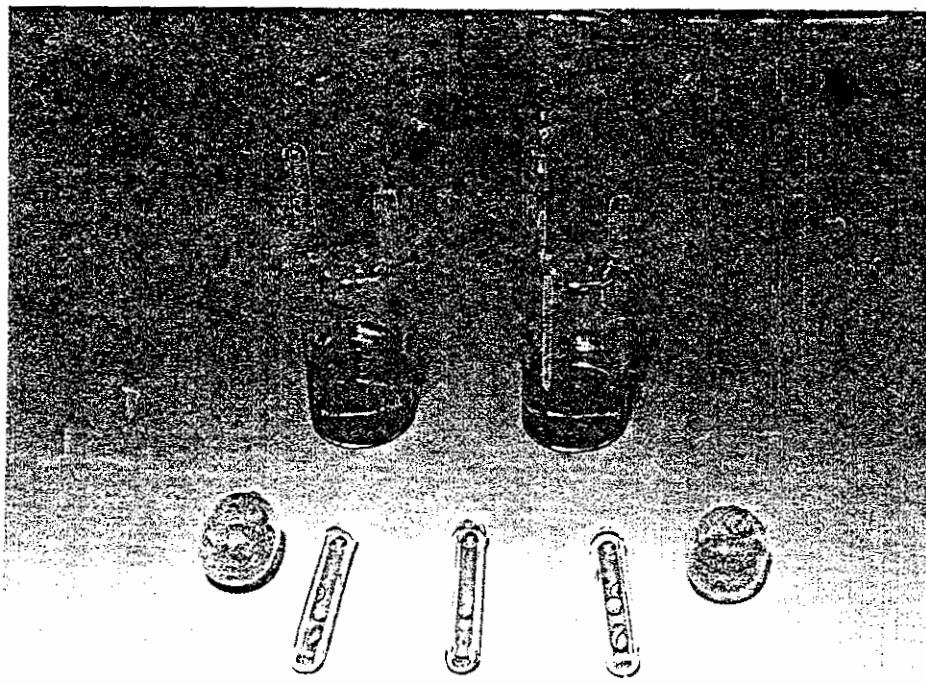


Figure 6 - Différents types d'ampoules de verre utilisés pour conditionner des échantillons liquides ou solides.

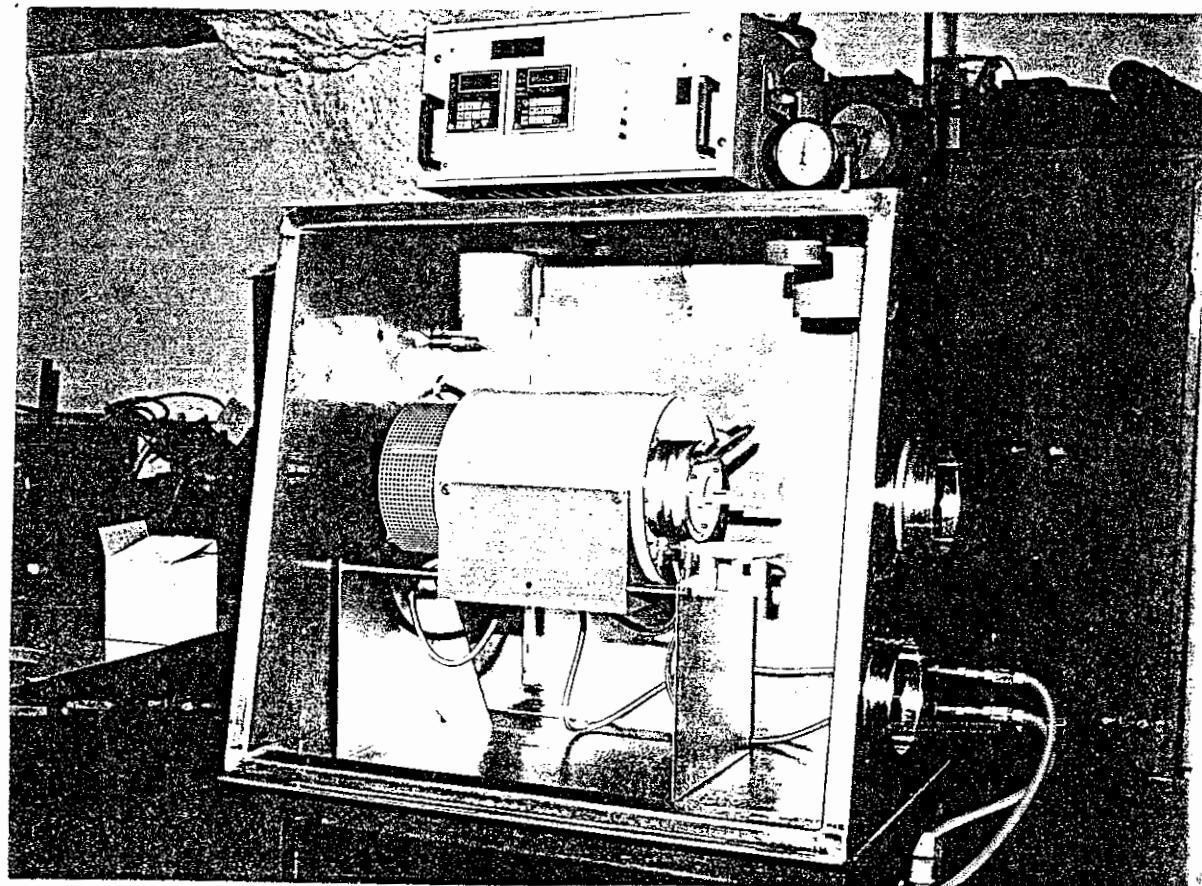


Figure 7 - Four ADAMEL FP15 avec son programmateur.

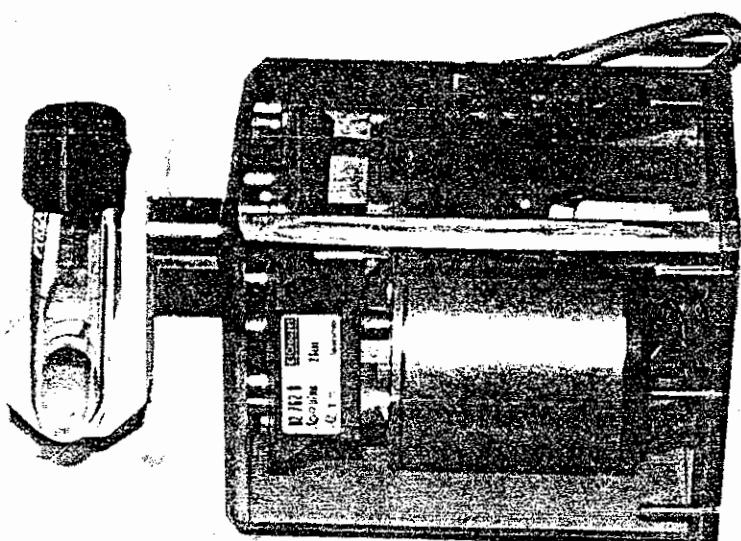


Figure 8 - Homogénéiseur utilisé pour l'oxyde de plutonium.

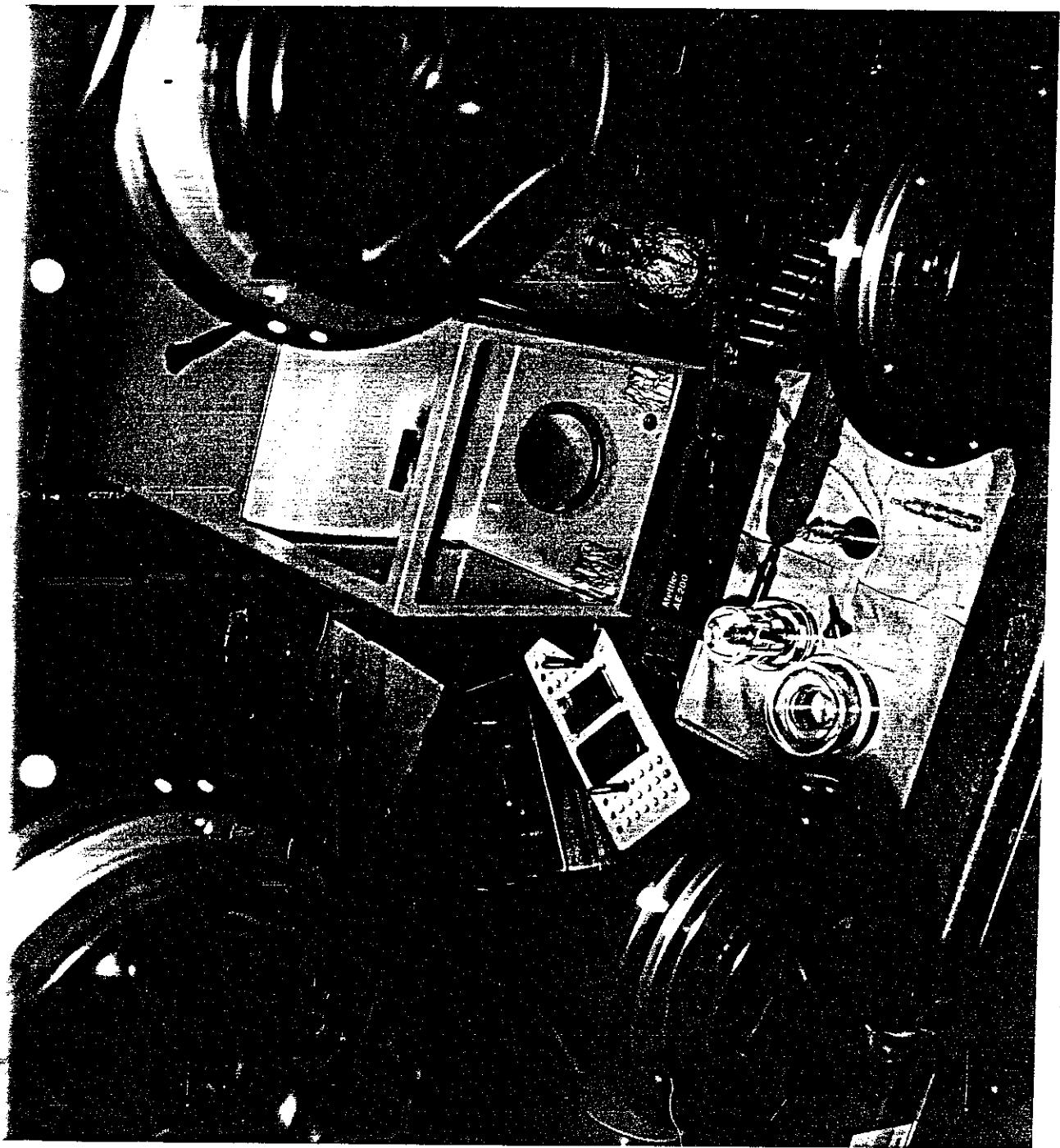


Figure 9 - Pesées des échantillons pour analyses différenciées.

WORKING GROUP ON HOT CELL AND REMOTE HANDLING TECHNOLOGY
1989 PLENARY MEETING - KARLSRUHE (RFA)

SCELLEMENT D'AMPOULES DE VERRE PAR FAISCEAU LASER EN BOITE A GANTS

ced IRDI
D.E.R.D.C.A.-D.C.A.E.A.-S.E.A.

LABORATOIRE DE METROLOGIE DES MATIERES NUCLEAIRES
CENTRE D'ETUDES NUCLEAIRES DE FONTENAY AUX ROSES, BP 6 - 92265 CEDEX FRANCE



BUT

STOCKER DES ECHANTILLONS REPRESENTATIFS D'OXYDE DE PLUTONIUM, OU DES ALIQUOTES DE SOLUTIONS D'URANIUM OU DE TRANSURANIENS EN VUE D'ANALYSES DIFFERENTES.

REALISATION

CONDITIONNER EN AMPOULES DE VERRE SCELLES.

APPAREILLAGE

LASER A CO₂ PICOUT

λ : 10,6 microns
P : 20 μ 150 watts
Classe 4

MIROIR PIVOTANT

BANC DE PURIFICATION JACOMEX

14 renouvellements / heure

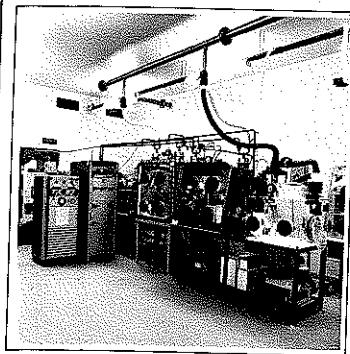
FOUR ADAMEL FP 15

T° maximale : 1500°

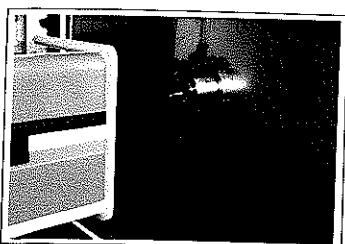
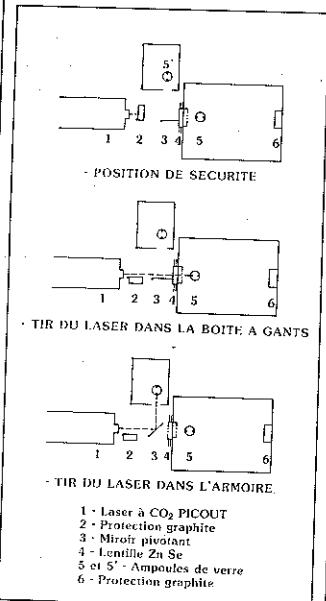
BALANCE METTLER AE 200

CONDITIONS OPERATOIRES

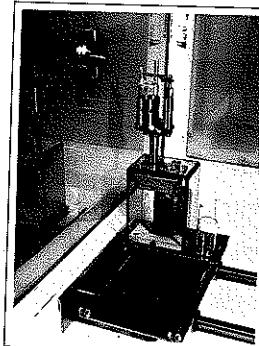
	Scellement	Recuit
Puissance watt	50 à 80	20 à 30
Rotation t/mn	20	20
Ø impact mm	5	15
Durée mn	1	5



INSTALLATION DE CONDITIONNEMENT



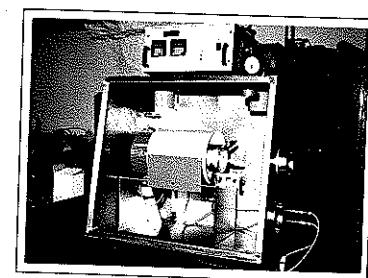
COLLIMATEUR AVEC LENTILLE Zn Se



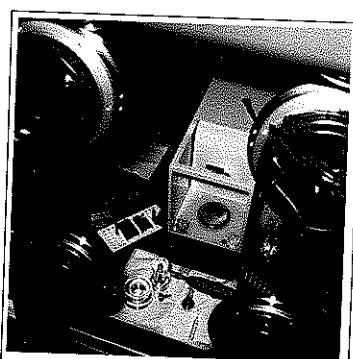
AMPOULE DE VERRE EN POSITION DE SCELLEMENT



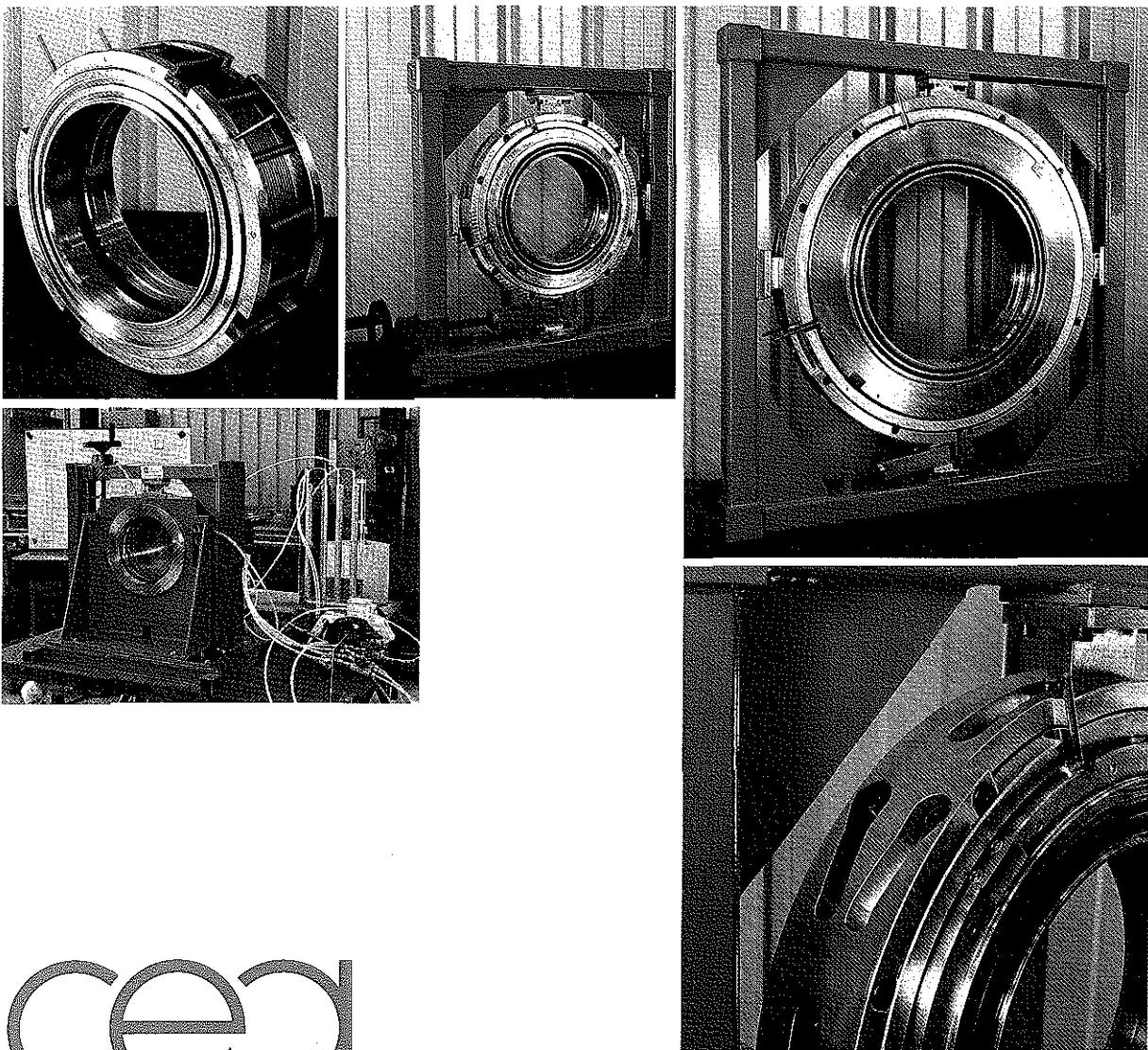
SCELLEMENT DES AMPOULES DE SOLUTION D'URANIUM NATUREL



FOUR UTILISE POUR CALCINER PuO₂



PESAGES DES ECHANTILLONS D'OXYDE DE PLUTONIUM



Photos LOMBARD - GABARRE PUBLICITE - Lyon

ced

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Telefax (33) 72 50 40 57

ELECTROCHEMICAL CORROSION STUDIES ON IRRADIATED STAINLESS STEELS

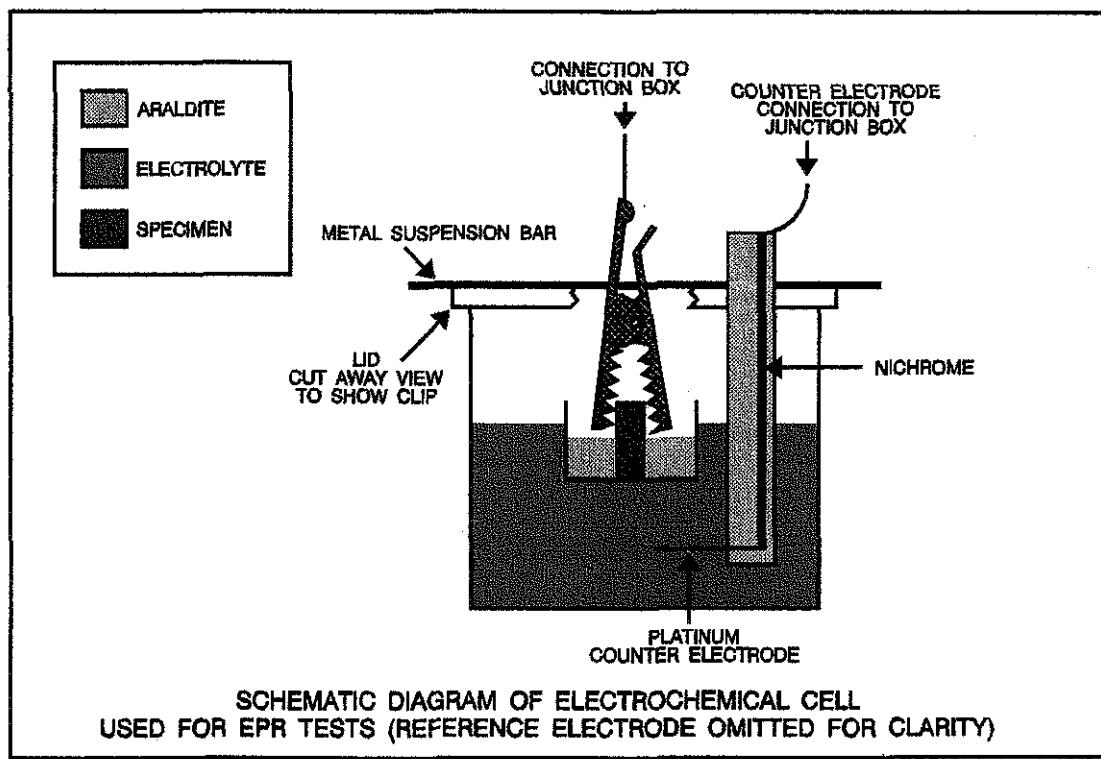


FIGURE 1

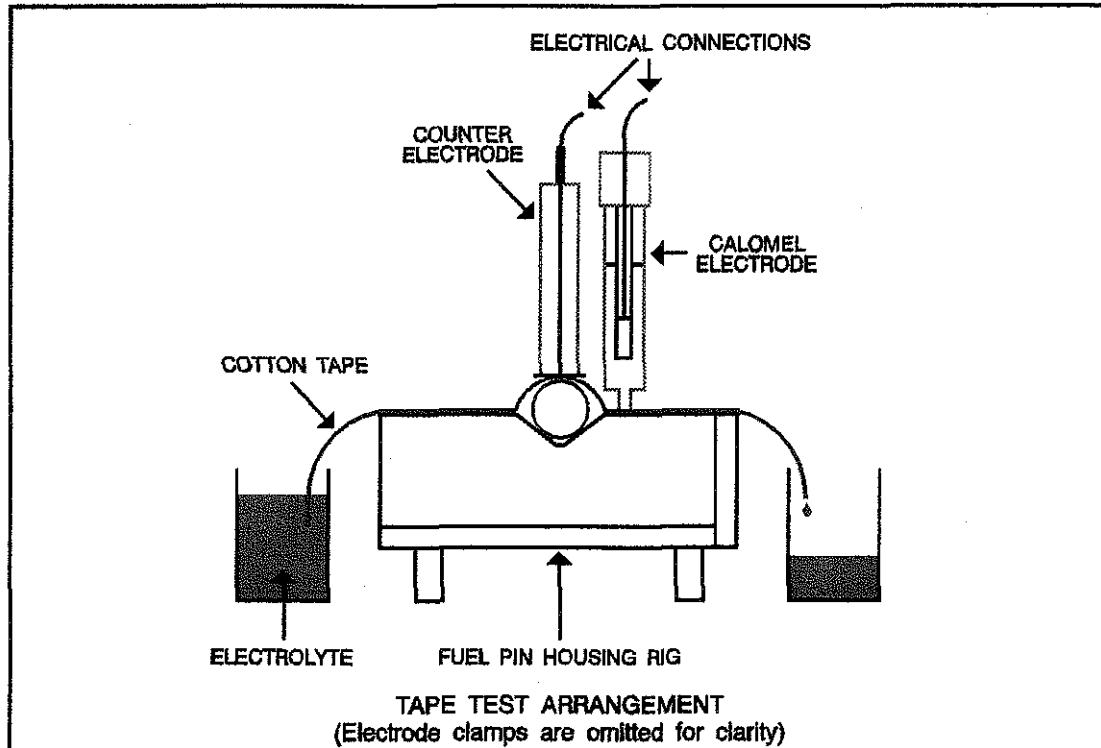


FIGURE 2



INTRODUCTION.

Stainless steels irradiated in thermal reactors can become sensitised to intergranular corrosion because of:

- Radiation induced segregation.
- Thermally induced sensitisation.
- Carburisation of external surfaces, eg by AGR coolant.

Electrochemical techniques for studying sensitisation and testing sensitised materials have been developed at Windscale.

THE EPR TEST.

The degree of sensitisation of a sample is determined using the electrochemical potentiokinetic (EPR) test.

In an EPR test the potentiokinetic curve of the material of interest is obtained by controlled potential sweep from the passive to the active region (activation) in a specific electrolyte. The test is carried out in a three electrode electrochemical cell. The potential of the specimen (or working) electrode, composed of the material of interest, is controlled relative to a standard calomel reference. A third electrode, the counter electrode, composed of platinum is used to pass current through the cell. The control potential is supplied by a potentiostat.

The potentiostat records current as a function of potential, the EPR response is a plot of current against potential. Sensitised materials are easily activated (show large current responses) whereas under ideal conditions unsensitised materials give a zero response.

Work on irradiated materials has employed standard transverse metallographic mounts as specimen electrodes. (These mounts consist of cut samples of irradiated material set in Araldite and enclosed in a circular plastic mounting ring.) Contact is made onto the rear of the mounts using a metal clip. The clip is fitted with a metal bar so that the mount can be suspended with only the polished face exposed to the electrolyte as illustrated in Figure 1.

The EPR tests are carried out in a polypropylene beaker fitted with a specially designed lid. The lid has a platinum counter electrode (see Figure 2) built into it and also has two circular openings so that the working and reference electrodes can be placed in the test electrolyte. This arrangement is designed for

ease of remote use and robustness. The in-cell test equipment is inexpensive and easily replaced. Metallographic examination after testing is used to assess the degree of intergranular attack and so to aid interpretation of current responses. Metallographic examination can also be used to investigate local sensitisation variations.

OTHER TECHNIQUES.

At Windscale a method for conducting electrochemical corrosion tests on ribbed CAGR fuel cans is under development. The basic concept is illustrated in Figure 2, electrolyte is made to flow slowly from one beaker to another along cotton tape. A section of wet tape is pressed against the fuel pin surface. Only the area wetted by the tape is exposed to the electrolyte. The reference electrode is placed "downstream" so that any chloride contamination of the electrolyte in contact with the fuel pin is avoided. Potentiokinetic and ac impedance tests have been successfully carried out using this arrangement on unirradiated fuel pin cladding sections.

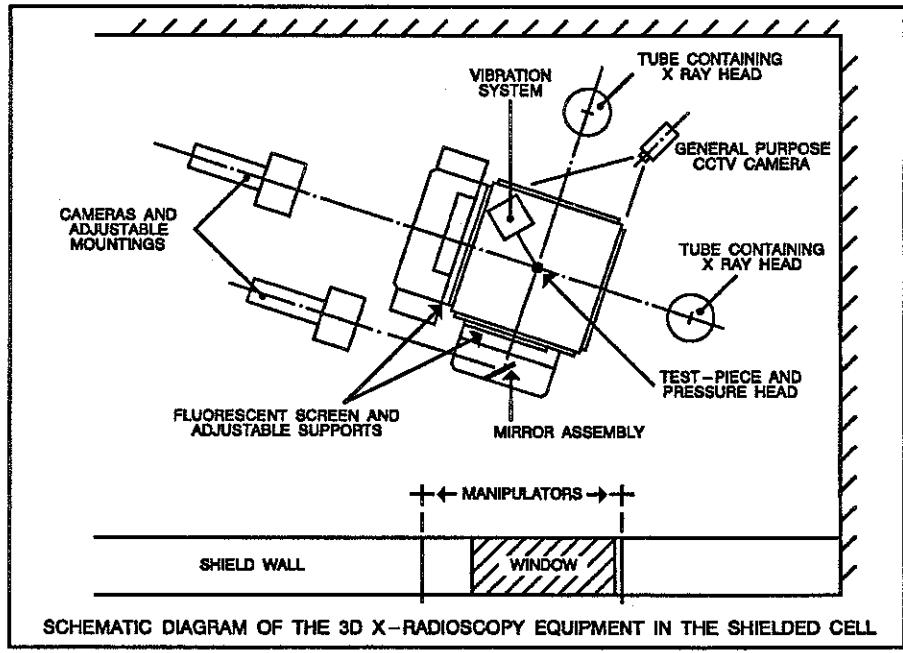
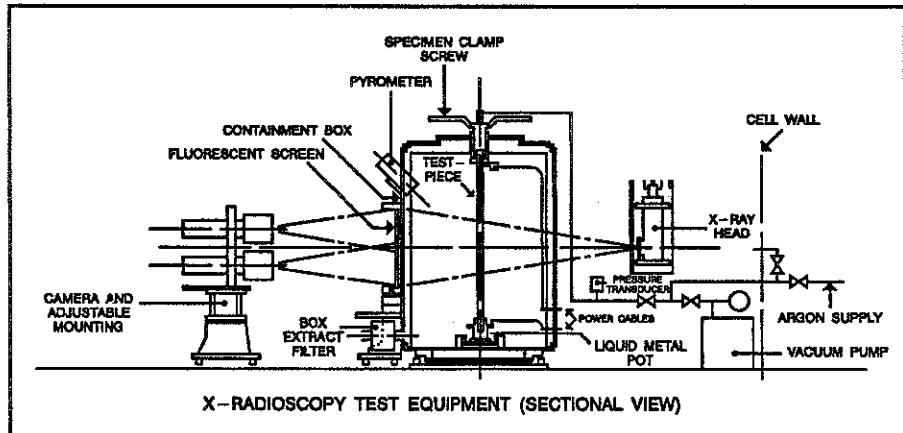
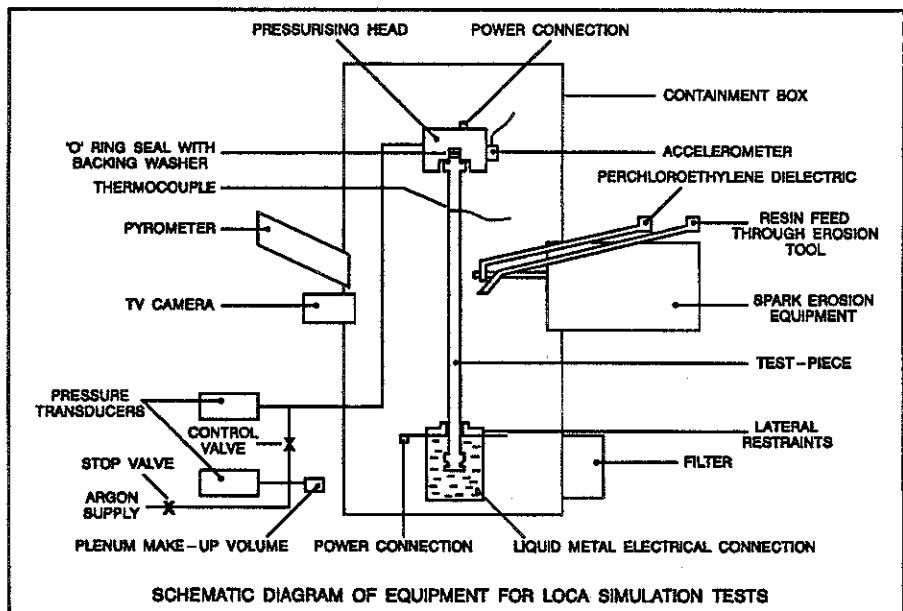
OTHER SERVICES.

Windscale Laboratory offers a range of services including irradiated fuel examination; manufacture of experimental fuel rods and assemblies; heat transfer, fluid flow and vibration studies; process and reactor chemistry, including radioactive waste management; decommissioning of nuclear plant; and the development of special handling and measurement techniques for radioactive environments.

ENQUIRIES

Manager, Marketing and Sales
Windscale Laboratory, UKAEA
Seascale, Cumbria CA20 1PF, United Kingdom.
Tel. 09467 71817. Telex. 64140. Fax. 09467 28989

X - RADIOGRAPHIC STUDIES OF FUEL RELOCATION DURING A SIMULATED PWR LOCA



AEA TECHNOLOGY



INTRODUCTION.

During a hypothetical PWR LOCA, extensive fuel cladding ballooning can occur. This can restrict the access of emergency coolant to reflood the reactor core. In most LOCA studies the fuel stack is presumed to remain intact along the rod centre. However, if the fuel column is eccentric during ballooning, azimuthal temperature gradients are introduced which lead to a decrease in cladding strain at rupture. This potentially important mechanism of limiting cladding ballooning has been investigated in the PIE facilities at Windscale. Earlier work has determined the fuel stack position inside ballooned cladding by spark-eroding a hole in the cladding and filling the ballooned region with resin prior to examination by X-radiography and sectioning (Phase 1). This method was superseded by real-time 2D X-radioscopy (Phase 2) which removed the possibility that the fuel might have moved during spark-erosion and resin filling. However, since only one X-ray head was used, this approach did not detect movement of the fuel stack in the direction of the X-ray beam. Therefore the technique was further improved to include two X-ray beams at right angles and thus allow 3D radioscopic analysis. This fuel relocation programme is providing information of direct relevance to the modelling of cladding ballooning in a LOCA.

This display illustrates the three techniques for ballooning tests, with the emphasis on the current 3D X-radioscopy system (Phase 3).

TEST EQUIPMENT FOR PHASE 3.

The two X-ray beams are provided by 160 kV Philips sets positioned to irradiate the test piece mutually at right angles. The X-rays are intercepted by two fluorescent screens of gadolinium oxysulphide and viewed by two closed circuit TV cameras sensitive to low levels of illumination, one directly and the other via a mirror. (The mirror is used in order to render the equipment more compact). The images from the CCTV cameras are displayed on a single monitor screen and recorded on video tape. Temperature measurement is by a Land infrared thermometer, pressure is measured by a Sangamo Weston pressure transducer system. The cladding is heated by an AC direct resistance technique and the temperature controlled by Eurotherm equipment. The current is applied through the top end fitting and a pool of molten, low melting point alloy in contact with the bottom end of the test-piece. Vibration, to simulate reflood quenching, is applied to the test-piece using a Ling Dynamics System electro-mechanical vibrator and transmitted to the test-piece by a rod contacting

the top fitting. The vibrator is fed by a white noise generator and the system is capable of producing vibration in the range 3Hz to 5kHz. The vibration induced in the rod is measured by an accelerometer attached to the pressure connection at the top of the test-piece. Reflood vibration has been measured previously on a large-scale non-active facility and the data obtained used to calibrate the accelerometer attached to the radioscopy rig. To produce the cladding ballooning the test-piece is evacuated, purged with argon and then pressurised with argon. The input power is controlled from the Land thermometer to follow a preset temperature ramp until 30-40% diametral strain has been achieved over the test-section (Simulated reflood vibration is applied during this period). The movement of the fuel column is monitored during ballooning on the CCTV monitor using a split screen generator so that the two orthogonal images can be viewed simultaneously. These images are recorded throughout the test and are also used to estimate the cladding strain. When the required cladding strain has been reached the test is stopped by switching off the power. The recorded real-time radiographic images are subject to detailed analysis with a Quantel image enhancement system.

These studies are funded by the Central Electricity Generating Board.

OTHER SERVICES.

Windscale Laboratory offers a range of services including irradiated fuel examination; manufacture of experimental fuel rods and assemblies; heat transfer, fluid flow and vibration studies; process and reactor chemistry, including radioactive waste management; decommissioning of nuclear plant; and the development of special handling and measurement techniques for radioactive environments.

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Manager, Marketing and Sales
Windscale Laboratory, UKAEA
Seascale, Cumbria CA20 1PF, United Kingdom.
Tel. 09467 71817. Telex. 64140. Fax. 09467 28989

- REMOTE HANDLING AND ROBOTICS GROUP -
HARWELL LABORATORY

P12

**VISUAL AND NON-DESTRUCTIVE INSPECTION
USING REMOTE HANDLING TECHNIQUES**

INTRODUCTION

The Remote Handling and Robotics Group of the Harwell Laboratory has carried out an inspection of a radioactive tank to prove its safety for continued use. The inspection consisted of visual inspection, mechanical measurements and ultrasonic crack and thickness investigations. The stages of the project included design and development of special equipment, mock up construction and operation; and finally the inspection itself.

DESIGN AND DEVELOPMENT

The tank diameter was 2m and height 2m with entry to the tank through the top via 100mm and 150mm openings. A proprietary manipulator system was selected for deploying the inspection equipment which could reach all parts of the tank. An overall view of the tank interior was obtained via a TV camera deployed through a 150mm opening on a simple boom giving pan and tilt motions. Lighting was similarly provided. To carry out the ultrasonic inspection probes had to be deployed with a set stand off and where the inspection was above the water level a couplant was supplied. For tank surface inspection the probe was mounted on a tripod arrangement so that the operator could feel that it was correctly positioned. Where tube thickness was to be measured special saddles were designed that held the transducer onto the tube. A spring clamp was used for location with the release being provided by the manipulator grip. For mechanical measurements a saddle device was again used with a bowden cable providing the traversing movement. A high resolution transducer was used to provide the signal. Visual inspection was by a high definition TV camera which was manually deployed by the manipulator. In all cases the inspection equipment was retained on a wire to ensure that retrieval could be achieved.

INACTIVE MOCK UP

Experience at Harwell has shown the considerable advantage of the use of an inactive mock up stage in the design and commissioning of active facilities. A mock up stage was included in this project to ensure that the equipment developed worked satisfactorily together with the proprietary manipulator and transducers and to prove the procedures. It was also of great value in training the personnel and achieving good team work. As a result of the mock up work the actual inspection went well and was completed within the allotted time thus giving a reduced plant downtime and minimising the dose to the inspection staff. Management confidence was increased and the risk of accident minimised.

THE INSPECTION

The inspection team consisted of a team manager, manipulator operator, TV camera operator, TV video recorder operator, ultrasonic inspection technician and material specialist. The manipulator insertion procedure and all other activities were rapidly achieved thanks to the practice gained on the mock up. The inspection was a complete success and a great deal of useful experience was gained in all aspects of the project.

For further information please contact

G V Cole
Remote Handling and Robotics Group
Engineering Sciences Division
Building 351.28
Harwell Laboratory
Tel: 0235 24141 Ext 4764
Fax: 0235 43 6138

- REMOTE HANDLING AND ROBOTICS GROUP -
HARWELL LABORATORY

P13

**HYDRAULIC MANIPULATOR DEVELOPMENTS
FOLLOWING 3 YEARS OPERATIONAL EXPERIENCE**

INTRODUCTION

Three years active experience has demonstrated that the Harwell Hydraulic Manipulator can provide reliable manipulation of heavy loads in process areas in the nuclear industry. During this period a number of specific developments and modifications have been implemented to improve reliability and to ease fault diagnosis and maintenance. In order to extend the potential range of application of the hydraulic manipulator a series of further developments are in hand.

GAITER SYSTEM

A novel gaiter system has been produced for the hydraulic manipulator that overcomes many of the disadvantages of current "hot side" gaiter systems. The system is described on the poster presentation.

FORCE REFLECTING MASTER ARM

In applications where visibility is poor or where the task involves a high degree of dexterity a sense of feel is important to the operator. An electric force reflecting master arm is being developed to provide this capability. The work is described on the poster presentation and on completion will enable the hydraulic manipulator to provide a robust and easily maintainable alternative to the electric servo-manipulator.

TOOLING SYSTEM

Standard MSMs can be easily replaced by the hydraulic manipulator and this makes it an ideal candidate for decommissioning activities. To enhance this capability a range of exchangeable end effectors or tools is being developed in conjunction with a tool change station. Tools under consideration are:

- Large shear
- Small shear
- Nut runner
- Screwdriver
- Nibbler

INDEPENDENT SLAVE ARM

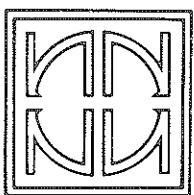
In some applications through wall mounting does not provide the flexibility of positioning to carry out the task or enable sufficient utilisation of the manipulator to be achieved. The design of an independent slave arm, which permits mounting at any selected site, has been completed and a prototype is being manufactured. Future developments may include a gantry mounted hydraulic manipulator.

SELF FAULT DIAGNOSTICS

The current control system is computer based to provide supervisory functions and a "teach and repeat" capability. To ease the identification of problems by non-technical operational staff a capability for self diagnosis of faults is being developed.

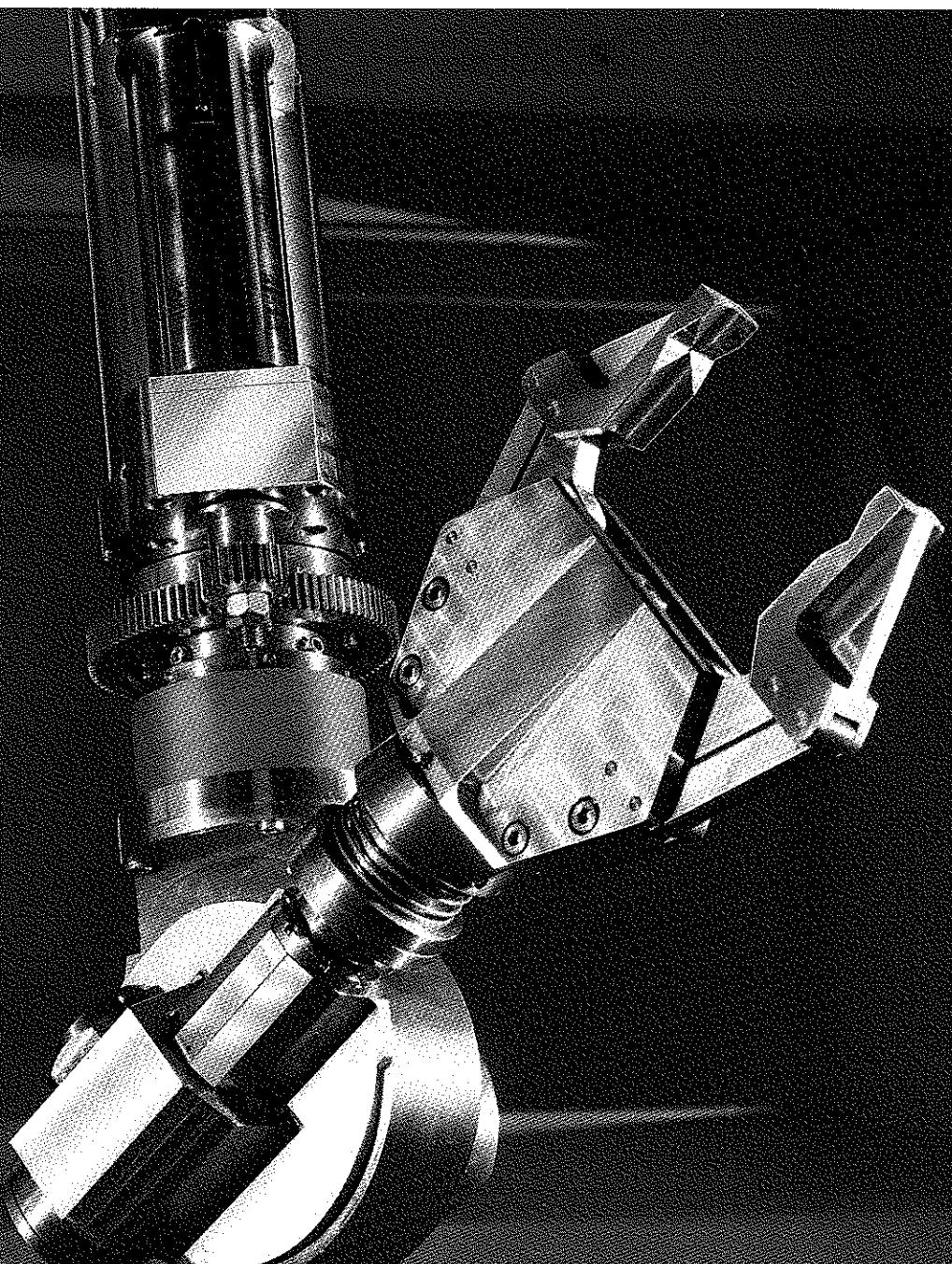
For further information on any of these topics please contact

G V Cole
Remote Handling and Robotics Group
Building 351.28
Harwell Laboratory
Tel: 0235 24141 Ext 4764
Fax: 0235 43 6138

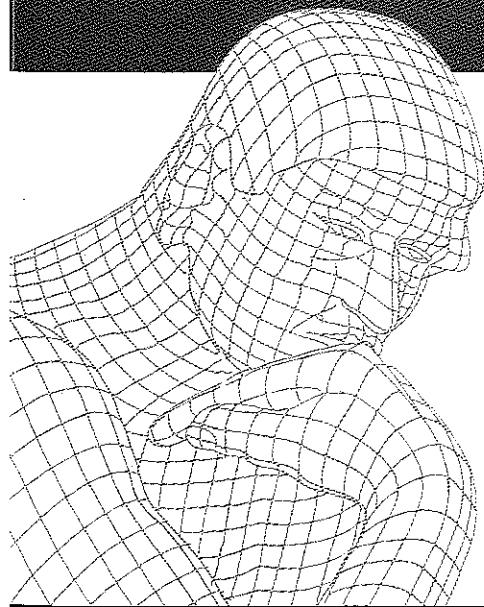


NORSON POWER LTD

P13



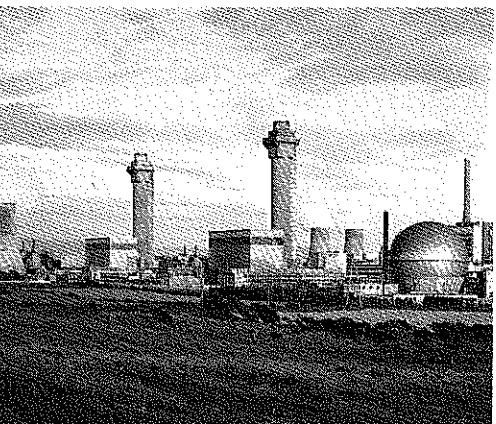
**HM10
HYDRAULIC
MANIPULATOR**



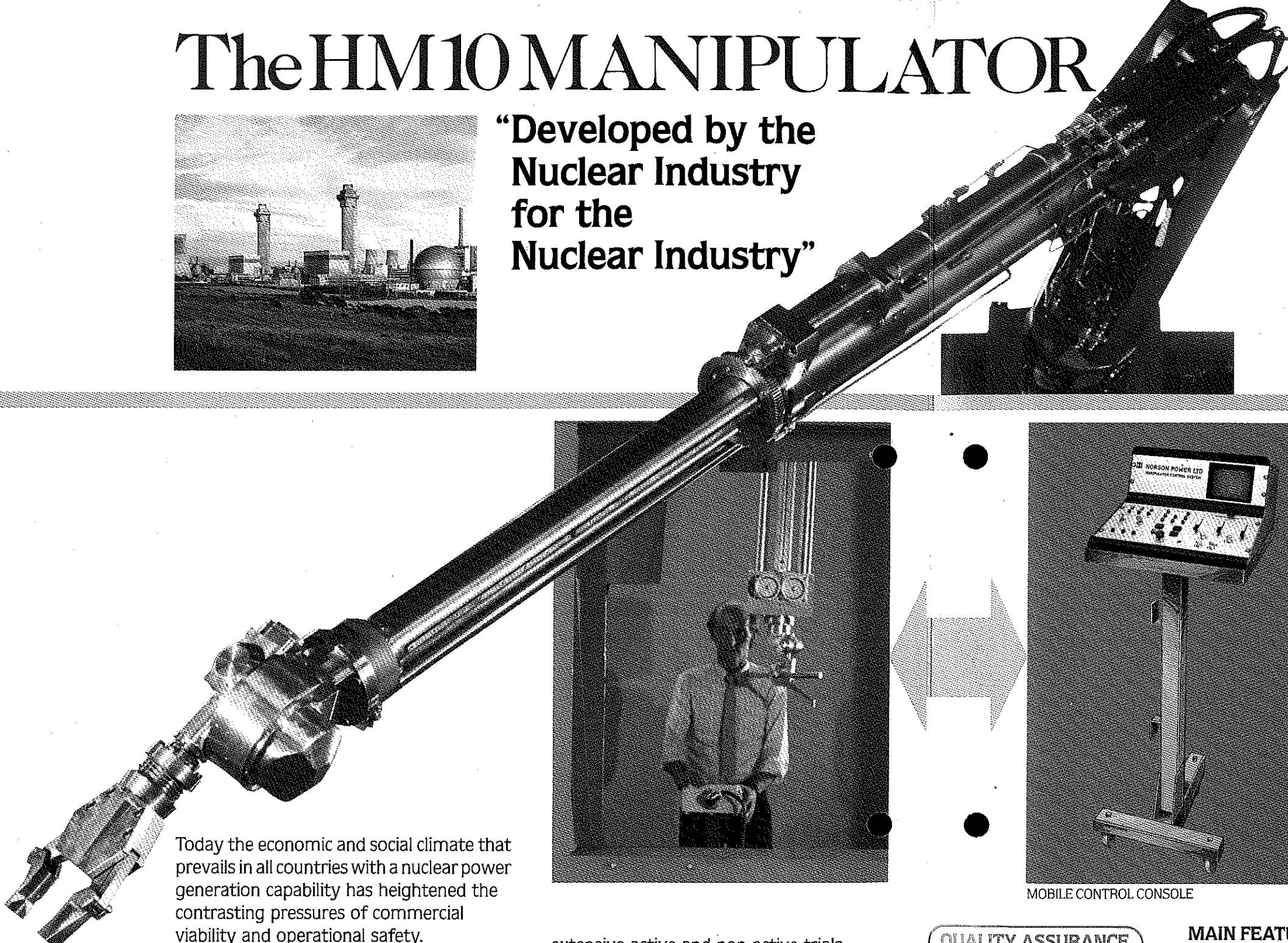
APPLIED INNOVATIVE ENGINEERING



The HM10 MANIPULATOR



"Developed by the Nuclear Industry for the Nuclear Industry"



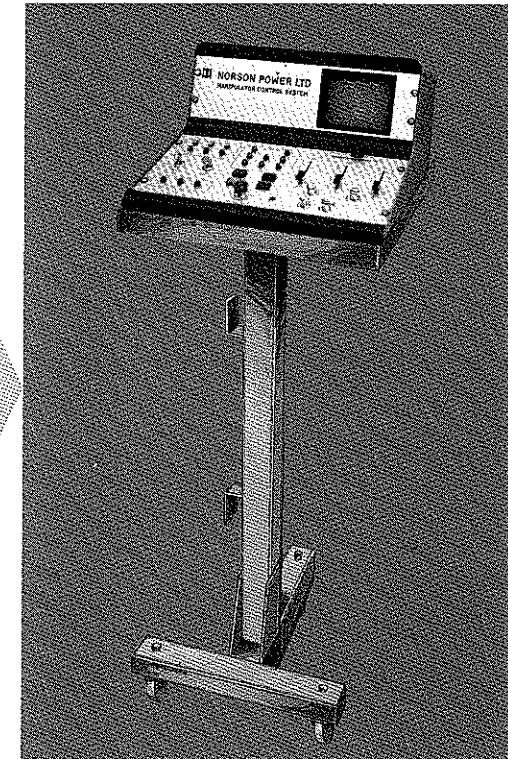
Today the economic and social climate that prevails in all countries with a nuclear power generation capability has heightened the contrasting pressures of commercial viability and operational safety.

This situation dictates that the highest component integrity and reliability is a prerequisite whether building new facilities or sustaining established ones.

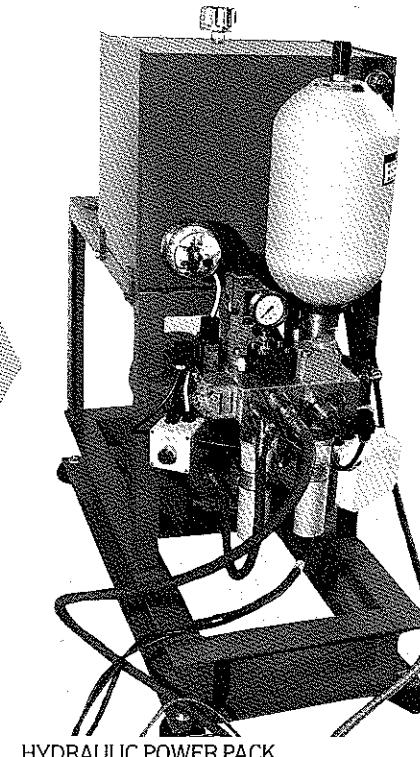
The **HM10 MANIPULATOR** from Norson Power has a major role to play in the realisation of these objectives. It is robust and totally reliable, yet its controls bring precision and versatility, all of which rapidly instills the confidence to perform the most complex of tasks effortlessly, again and again. These claims are not without foundation, this Manipulator is the product of many years development, including

extensive active and non active trials. In fact, conceived by the United Kingdom Atomic Energy Authority (UKAEA) at their Harwell Laboratory to satisfy a call for reliable remote handling equipment, it is no idle boast that it was developed by the Nuclear Industry for the Nuclear Industry.

So why commit yourself to high capital expenditure and be tied to an electro/mechanical power manipulator? Or channel vital resources into the operation and maintenance of mechanically linked master slave manipulators, when the solution stands before you. The HM10.



MOBILE CONTROL CONSOLE



HYDRAULIC POWER PACK

The HM10 Manipulator features an 8 function hydraulically operated **Slave Arm** which may be posted in and out of most radioactive cells.

The operator controls the **Slave Arm** from a **Mobile Control Console** in a closed loop. Potentiometers at each joint provide the feedback signal and a bank of servo valves the vital electronic/hydraulic interface. The console which may be moved about the cell face, incorporates an array of control features and a visual display unit (VDU) which provides continually updated operational information.

The **Hydraulic Power Pack** which provides cool, clean fluid on demand to single or multiple manipulators is mounted outwith the cell and is fully portable.

As an option a demountable **Master Arm** offering full spatial correspondence to the operator is available and may be used in conjunction with the **Mobile Control Console**.

MAIN FEATURES

ROBUST CONSTRUCTION

HIGH PAYLOAD

FULL OVERLOAD PROTECTION

EASY TO INSTALL

SIMPLE TO OPERATE

TOTAL MATERIAL COMPATIBILITY

RANGE OF CONTROL FEATURES

EASY DECONTAMINATION

ONGOING DEVELOPMENT PROGRAMME

FULL CONSULTATIVE & TECHNICAL SUPPORT SERVICE

Low cost of ownership

30kg (66lbs) Manipulative

Damage Prevention

Suitable for new and existing facilities

Low operator fatigue

See specification

See below

Minimal downtime

QUALITY ASSURANCE

Approved by the International Standards Organisation to:
ISO 9001
(BS 5750 Part 1)



APPROVAL CERT. NO. 840028

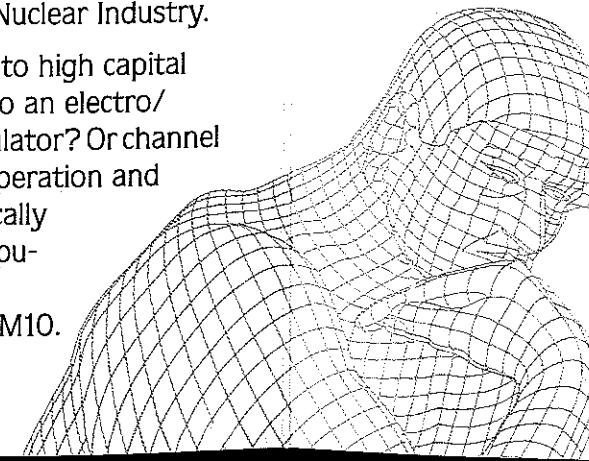
CONTROL FEATURES

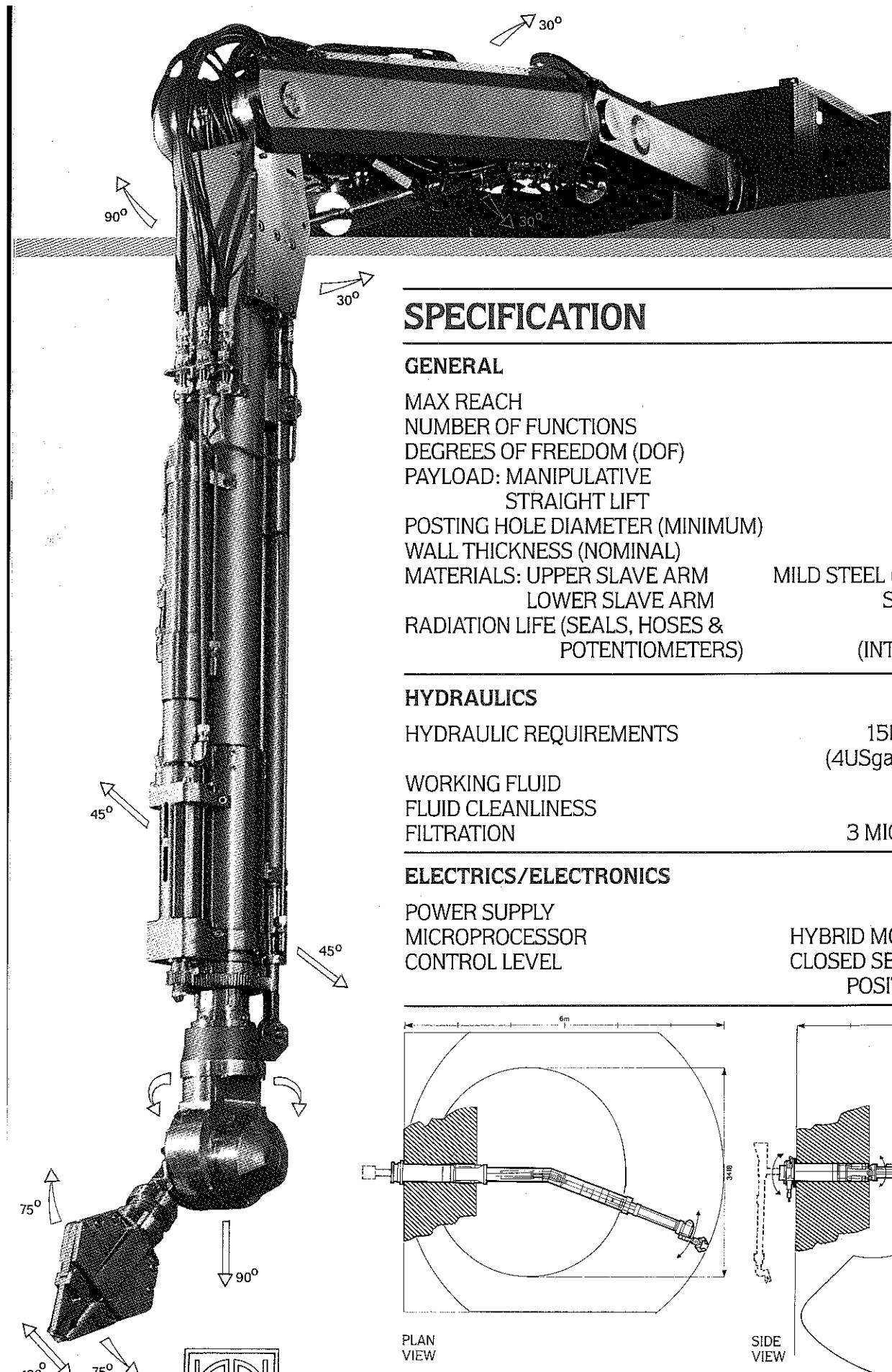
Multiple Teach & Repeat • Individual Function Freeze • Adjustable Envelope Limits
Force Feedback*

* To be available shortly

OPTIONS

Master Arm • Gaiter Systems • Jaw Change Station • Fault Diagnostics





SPECIFICATION

GENERAL

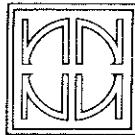
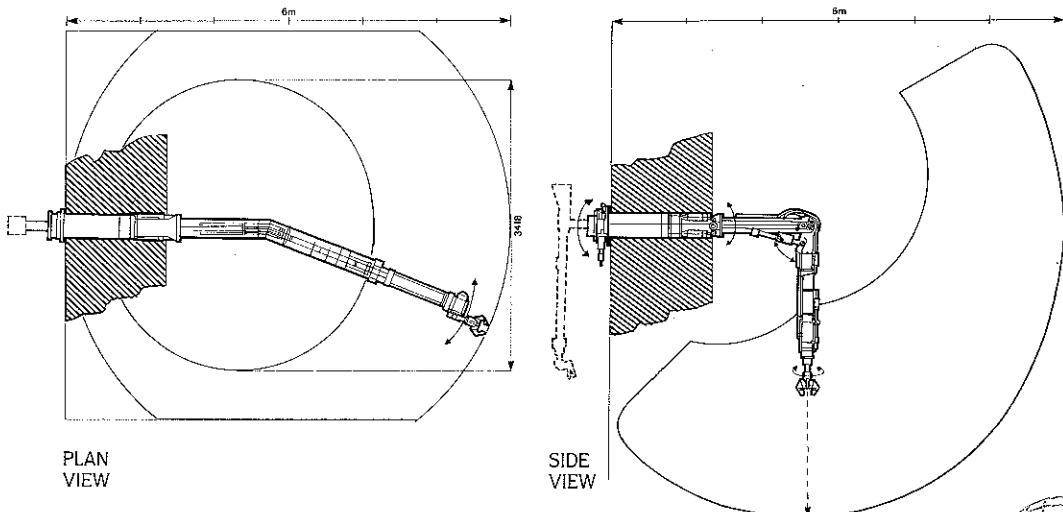
MAX REACH	4.1m (13' 5")
NUMBER OF FUNCTIONS	8
DEGREES OF FREEDOM (DOF)	6
PAYLOAD: MANIPULATIVE	30kg (66lbs)
STRAIGHT LIFT	350kg (770lbs)
POSTING HOLE DIAMETER (MINIMUM)	254mm (10")
WALL THICKNESS (NOMINAL)	1220mm (4'0")
MATERIALS: UPPER SLAVE ARM	MILD STEEL (NICKEL PLATED)
LOWER SLAVE ARM	STAINLESS STEEL
RADIATION LIFE (SEALS, HOSES &	1×10^8 RADs
POTENTIOMETERS)	(INTEGRATED DOSE)

HYDRAULICS

HYDRAULIC REQUIREMENTS	15lt/min@ 210 BAR (4USgal/min@ 3000psi)
WORKING FLUID	WATER GLYCOL
FLUID CLEANLINESS	TO NAS6
FILTRATION	3 MICRON ABSOLUTE

ELECTRICS/ELECTRONICS

POWER SUPPLY	110/240V AC
MICROPROCESSOR	HYBRID MOTOROLA 68000
CONTROL LEVEL	CLOSED SERVO LOOP WITH POSITION FEED BACK



NORSON POWER LTD

39 CLYDESMILL PLACE GLASGOW G32 8RF SCOTLAND UK
Tel. No. National 041 641 7671/2 Fax: 041 641 0495
Internat. +44 41 641 7671/2 Telex: 778295 Norson G

AUTHORISED DEALER

P14

- REMOTE HANDLING AND ROBOTICS GROUP -
HARWELL LABORATORY

NUCLEAR ENGINEERED ROBOTICS FOR HOT LABORATORIES

INTRODUCTION

At the Hot Labs Meeting in 1985 it was proposed that robots could present cost effective alternatives to man and conventional manipulators in nuclear facilities. Since then, the Remote Handling and Robotics Group at Harwell Laboratory have completed fundamental studies into what is needed to make this possible. The main obstacles to be overcome were:

- providing a teleoperation interface to a robot controller for man-in-the-loop operation
- nuclear engineering a robot to allow operation in radiation environments and ease maintenance operations.
- develop robust radiation tolerant viewing systems.
- validate the option by application studies and inactive trials

All four obstacles have been systematically addressed, and the Nuclear Engineered Advanced Telerobot [NEATER] is being constructed and will be operational by the end of 1989. Robust teleoperation interfaces have been built and extensively tested. Radiation tolerant stereoscopic TV systems have been constructed, continuing the development of non-hardened 3D systems. Inactive demonstrations of telerobotic operations such as decontamination and decommissioning have been accomplished, and active trials of the system are planned.

THE TELEOPERATION INTERFACE

The Harwell Input Controller [HIC] is built around a Research Machines VX-20 computer with a 80386 microprocessor and 80387 co-processor. HIC takes commands from two three degree of freedom joysticks or a six degree of freedom force ball, allowing an operator to drive the robot tool at full speed throughout its operational envelope. Singularities and joint constraints are managed by HIC as it contains a full description of the manipulator kinematics. HIC interfaces directly to the standard VAL robot controller, and the robot can be driven in all six degrees of freedom simultaneously in joint world or tool co-ordinate systems. Constrained degrees of freedom can be set to give priority to one, two, three or any number of axes to assist straight line, planar or offset planar motions.

NUCLEAR ENGINEERING AN INDUSTRIAL ROBOT

We have selected the Unimation PUMA robot as the ideal manipulator for nuclear engineering. NEATER is based on a clean room PUMA 762 robot, which has a full speed payload of 20kg. The arm design has been thoroughly assessed, in conjunction with Stäubli Unimation, to ensure that all components are suitable for nuclear applications. In addition, improved seals on all joints and a modified forearm which can be easily detached will help maintenance operations. A reduced base height cuts down the weight of the arm. At this stage NEATER is suitable for low-medium activity applications in hot labs. Continuing work in improving radiation tolerance includes back fitting of highly-tolerant devices so that the arm can endure more than 10^6 Gy. The NEATER will be delivered to Harwell in November 1989 and the backing fitting of components will be complete in early 1990.

3-D TV

Robust stereoscopic TV [3-D TV] systems have been built at Harwell for the last four years. Currently we have completed a radiation tolerant [$>10^4$ Gy] camera system for in-reactor applications. The camera is designed to fit into master slave manipulator ports for use in hot labs. At lower radiation levels, colour CCD systems can be used, and our experience in many human factors evaluations of different viewing configurations has shown that definite advantages are gained by using 3-D TV where direct viewing is difficult or impossible.

APPLICATION STUDIES AND TRIALS

We have completed several trials and demonstrations of telerobotic systems for applications such as decontamination and decommissioning. Most recently we have carried out extensive cutting operations using a telerobot and modified hand tools, for glovebox decommissioning. We use a computer-based kinematic model of the telerobot and the workpiece to ensure that the task can be completed using available tools and deployment systems. This avoids the iterative process in building full size mock-ups. We then use the resources of the Robotics Demonstration Facility to prove the validity of the simulation and convince the customer that telerobotic operation is both a feasible and low risk option.

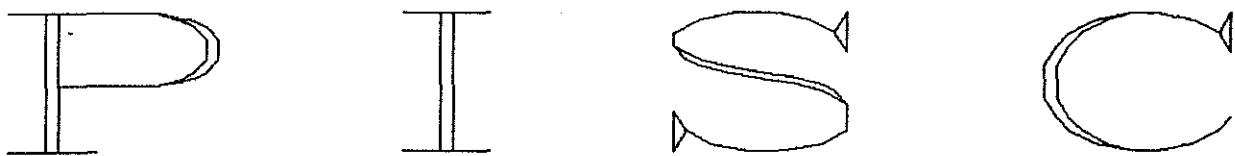
For further information, please contact:

Ed Abel

Remote Handling & Robotics Group
Engineering Sciences Division
Building 351.28
Harwell Laboratory

TEL NO: 0235 24141

FAX NO: 0235 436138



PROGRAMME FOR THE INSPECTION OF STEEL COMPONENTS

SHORT SUMMARY

The PISC Project has the general objective of assessing procedures and techniques in use for the inspection of pressure components (in particular the vessel and piping).

The Series of projects for the Inspection of Steel Components carried out since 1974 under the auspices of the CEC/JRC and the OECD/NEA is a major international effort to better assess the capability and reliability on Non Destructive Inspection procedures of structural components.

Three projects are centered on the Ispra Joint Research Centre which in its roles as Operating Agent and Reference Laboratory manages the programme and provides with the participants of EC countries approximately half of the programme funding; the other half comes via contributions in kind from the non-EC participating countries. OECD/NEA provides the Secretariat of the PISC Managing Board, consisting of representative of 15 countries (8 EC and 6 non-EC countries).

The programme is now in its third phase (PISC III project); during the next four years, the activities will concentrate on the validation of the PISC II results (e.g. modification of the ASME Inspection Codes) on real structures containing real service defects and the extension of the PISC methodology on most important structural components made of different materials. Most of the PISC test assemblies and structure pieces are representative of (or are coming from) nuclear reactor components.