DISMANTLING OF THE IRRADIATED FUEL ELEMENT CELL AT VANDELLOS I NPP

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1. INTRODUCTION

The general Decommissioning and Dismantling program for the Vandellós 1 NPP (DDP) includes the Performance of the Dismantling Plan for Active Parts (APDP), which affects the so-called Radiological Intervention Units (RIU).

The Irradiated Fuel Handling Cell (IFH Cell) is one of the Intervention Units, and is more specifically one of those defined as being Special Elements. This is due to the fact that its special radiological conditions make it necessary to add the decontamination of the corresponding equipment and systems to the dismantling activities themselves.

In accordance with the strategy for application of the ALARA Program for the APDP, the activities performed on the so-called Special Elements are subject to specific radiological risk Optimization and Minimization Plans. In this respect, the IFH Cell constitutes a scenario with very high levels of alpha and beta-gamma emitter surface contamination, significant area dose rates, with the probable presence of hot particles, and the forecast that the dismantling activities would generate important levels of atmospheric contamination due to the resuspension of aerosols contaminated with transuranic elements.

The ALARA nature of the present article rests also on the intention to obtain conclusions and lessons learned serving as experience with regard to the optimization of subsequent interventions in the process of dismantling the Pools Hall or surroundings, with comparable radiological problems.

2. DESCRIPTION OF CELL AND SCOPE OF WORK

The IFH Cell consists of an enclosure measuring 3.5 meters by 3 meters at its base and 4.5 meters in height, with structures and systems prolonged below the floor level of the main enclosure to a depth of 4.3 meters. The entire structure is surrounded by concrete walls measuring between 1 meter and 1.5 meters in thickness.

The cell is located inside the Pools Hall and communicates with it via two accesses, one at the side, fitted with a sliding door for personnel access, and an upper access fitted with a removable plug for the insertion and removal of equipment and materials. The enclosure also communicates via a tunnel (downcomer) with the “miscellaneous storage” Pool. This downcomer is used to transfer the fuel elements between the pools and the Cell, under wet conditions.

The cell is equipped with a specific ventilation and filtration system that keeps it isolated, from the environmental point of view, from the rest of the Hall. It is also fitted with remote control equipment which may be operated from outside for the performance of tasks such as the handling of irradiated fuel elements, the inspection of degraded elements, the handling of activated parts, the conditioning and packaging of fuel elements, etc.

In the situation prior to the dismantling work, the interior of the cell was occupied by a large quantity of miscellaneous material (cell equipment, work tables, tools, wastes, packages, etc.), all with a high level of contamination and significant dose rates.

- Dose rates – range of values - (mSv/h)
  - Area: 1.5 – 10.0
  - Contact: 4.0 – 25.0
- Removable surface contamination – range of values - (Bq/cm^2)
  - Beta – gamma: 1.29E+3 – 8.2E+3
  - Alpha: 2.34E+1 – 2.5E+2

The main isotopes detected are as follows:

- Gamma: Co-60, Cs-134, Cs-137, Eu-154 and Eu-155.
- Beta: Sr-90
- Transuranic elements: Am-241, Pu-238, Pu-239+240 and Pu-241.
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For the specific work described in this article, performed within the APDP, the operational objectives were to dismantle the interior contents of the Cell: materials, equipment, including the systems, and to reach a suitable level of decontamination of the remaining interior walls following this task. To these activities were added the collateral activities arising from the segregation and conditioning of the wastes generated during the work. The time interval used was from 14th July 1999 to 9th November 1999.

The parallel objectives, from the point of view of RP, were as follows:

- The achievement of certain values of surface contamination on the inner walls of the Cell, facilitating the future task of demolition of the structure.

- The removal, confinement and management of the internal wastes which, due to their special nature, might constitute an important factor of radiological risk if not definitively managed.

These objectives were to be achieved by applying Radiological Protection criteria guaranteeing that the doses associated with the work (by any exposure route) were as low as reasonably achievable, specifically eliminating those due to the incorporation of contamination containing alpha emitters via inhalation.

The approach adopted for the work, taking into account the aforementioned objectives and requirements, required the development of application-specific documentation and previous collaboration agreements with authorized organizations carrying out certain types of analysis (evaluation of biological samples).

3. PROJECT PERFORMANCE

Schedule

This point presents schematically the performance of the work, in accordance with its different phases, the partial scope of which corresponds to the different work authorization requests (WAR's) opened, and with the previous and subsequent periods for the necessary arrangements and drawing up of the associated documentation. Overall, the schedule began on 14th July 1999 and finished on 9th November of the same year.

The following table summarizes certain of the basic data on the different phases of the work.

PERIOD	WAR	ACTIVITIES	Man-hours
14/07 to 2/8	EJE-0052/101-99	Conditioning of zones and assembly of confinement AES	3240
2/8 to 17/8	EJE-0052/101-99	Movement of IFH roof materials and assembly of upper AES	0105
13/8 to 9/11	EJE-0052/102-99	Decontamination and dismantling of equipment located inside the IFH cell	1056

Note:
- The figures for man-hours are approximate.

Techniques and resources used

As part of the technical documentation required from the contractor, the need to submit certain procedures was specified. These procedures were to specifically establish the methods and equipment to be used depending on the characteristics of the surfaces to be decontaminated and the nature, physical conditions and layout of the material of the equipment to be dismantled. Likewise, procedures or documentation were requested explaining the previous waste conditioning, treatment and management tasks (installation of breathing air system, AES).

In summary, the criteria were as follows:

- In-depth evaluation of the ALARA "profitability" of applying effective cutting methods, but that might contribute to the resuspension of radioactive aerosols.
- Ruling out of the use of chemical compounds susceptible to generating physical risks or increasing radiological risks.
- Use of equipment and tools minimizing the possibilities of vibration, knocking, etc.
- Limitation of and justification for the use of rotating or thermal cutting tools or any other that might indirectly complicate the radiological conditions by mobilizing aerosols.

General sequence of performance:

- Conditioning and assembly of external structures (AES, extension of air line, filtered suction line, transit zones, material procurement areas, etc.).
- Remote removal (remotely manipulated) of loose irradiating wastes from inside the cell.
- Manual removal of other loose materials.
- Closed circuit suction of dust and contamination accumulated in the cell via HEPA filters and under dry conditions.
- Manual or machine-operated moist wiping (decontaminant solution).
- Application of peelable paints in treated areas.
- Dismantling of lower fixed equipment.
- Dismantling of upper fixed equipment.
- Dismantling of equipment and systems below the floor level.
- Dismantling of interior of fuel element downcomer.
- In parallel with the above, decontamination and cleaning of work area and conditioning of wastes generated.
- Final decontamination of the remaining structure.

4. APPLICATION OF ALARA PROGRAM AND RADIOLOGICAL CONTROL

Planning

As part of the initial analysis of the work to be performed in the IFH cell, an ALARA group was set up for work forecasting, tracking and control. This was made up of members of the Performance, RP and Operations and Maintenance Services and of members of the personnel of the contracted company involved, and its essential functions were as follows:

- Analysis of specific activities.
- Planning of specific tasks.
- Work tracking.
- Analysis and acceptance, where applicable, of work procedure modifications,
- Analysis of ALARA results and reports generated.

Emphasis was laid in this program on the role of the Contractor company as a prescriber of the ALARA culture among its workers. The objective adopted was to prevent all doses due to internal contamination and also those cases of external contamination that might cause a significant skin exposure above the depth dose. For this purpose, the basic criteria to be applied from the radiological point of view were established, divided into various sections: Planning, Specific personnel training, Radiological control during work performance (persons and work areas), Actions in the event of incidents and Evaluation of results.

Tracking of the work was accomplished by way of periodic meetings including the participation of the IFH cell work coordinator, the Vandellós I ALARA coordinator, a representative of Operations, a representative of the Operations RP department, the individual responsible for contractor work and the contractor's ALARA technician. Other persons also participated occasionally, depending on the subjects to be dealt with, such as the Safety and Hygiene personnel, Medical Services, etc.

In view of the historic knowledge of the operations performed in the cell, and the data obtained from the limited radiological characterization activities carried out previously, the initial situation of the planning process included some uncertainties and many indeterminations, which are summarized below:

- Inside the cell there were high occasional accumulations of contamination containing TRU's arising directly from the handling of degraded fuel elements.

- The physical nature of this contamination made it easily resuspendable.

- The contamination by strong beta emitters (fission products) was also very high.

- The location of the irradiation hot spots led to the suspicion that there might be remains of activated materials and possibly discrete radioactive particles (hot particles).

- The information on the constructional characteristics of various systems and components included in the cell was very limited in certain cases.

- There was no information on the radiological situation of inaccessible areas of the systems and structures of the cell.

Fortunately, the physical configuration of the cell itself provided a confined environment that facilitated the control of the ventilation and the levels of depression required. These conditions were subsequently to be extended to the access and exit areas to be conditioned (AES).

<u>Implementation of optimization activities and protection and conditioning resources</u>

On the basis of the radiological characteristics of the associated risks, and the conditions that it was foreseen would arise during performance of the work, the following was considered to be necessary:

- To obtain the best possible performance (ALARA) from the remotely controlled operating resources available in the cell, using them for the removal and confinement, in hermetically sealed packages, of small, highly activated parts present in the cell, thus reducing the levels of radiation prior to the access of the personnel.

- To have available and use personal protection resources against contamination (surface and atmospheric), guaranteeing a sufficient degree of isolation under all conditions. For this purpose, the RPS and S technicians visited the centres at which this equipment was manufactured, to gain first-hand knowledge of its characteristics and methods of use, and references on results obtained in use at facilities and for work having characteristics similar to those expected to be encountered in the IFH cell, and in general in environments with very high levels of surface and atmospheric contamination by alpha emitters.

- The personal protection equipment had to be integral, ventilated (with a certain degree of positive internal pressure), impermeable and capable of being used simultaneously (double barrier) with a complementary internal system consisting of a face mask supplied with breathing air from the outside, via a filter (P-3). The device was required to guarantee the complete respiratory isolation of the worker with respect to the atmosphere, not only inside the cell but throughout the entire process of undressing and removal of the protection, ensuring an adequate level of added protection (filtration of breathing air) in the event of loss or disconnection of the external supply (Fig. 3).

- Assembly of two AES's, one in the access/exit area to and from the cell, with double routes compartmented into isolated enclosures for the exit phases: decontamination shower for outer clothing and undressing, and another AES located on the roof of the cell and communicated with it via an upper plug. This would be used for the operations performed in a confined environment and consisting of placing the chests – previously loaded with irradiated material inside the cell, by means of remotely controlled equipment – into the containers (Fig. 2).

- The constructional design characteristics of the cell access/exit AES guarantee the maintenance of an important level of depression (measurable) with respect to the rest of the Pools Hall areas, also ensuring a flow of air from the cleaner compartments to the cell itself. There should also be hermetically sealed compartments with air-locks for the loading, sealing and removal of the containers, and drums for dismantling and secondary wastes.

- Establishment of action instructions for medical or radiological contingencies.

- Extension of the breathing air supply network by means of quick connectors and all the extensions required such that the independent supply from the exterior be maintained available to the workers during undressing operations inside the AES's. (Fig 1).

- The specific conditions of this work, and the use of breathing air, made it advisable to deliver specific training for the personnel that would intervene in the different work phases.

Dosimetric estimation

The overall estimate (corrected after insight had been gained into the conditions following the removal of irradiating material) was 6.085 mSv x p.

Radiological control

The radiological control of the work and workers was accomplished in accordance with the initial plan (Radiological Control and Surveillance Procedure for IFH Cell dismantling work). In summary, this control was based on the following:

Work Zones:

- Continuous supervision of work
- Frequent surveillance of levels of radiation and surface contamination.
- Continuous surveillance of the levels of atmospheric contamination in access/exit areas and outside the cell, by means of continuous measurement beacons (alpha and beta-gamma) with local and remote value indication and alarm signals.
- Complementary continuous environmental sampling (outside cell) for subsequent analysis in the laboratory.
- TLD dosimetry of environmental beta dose (surface dose) inside the cell.

Workers:

- Previous and final control in CRC
- Nasal smears following each intervention in the cell.
- Control of personal alpha and beta-gamma contamination at exit from Pools Hall.
- Periodic collection of specimens of excrement for analysis of internal contamination due to the incorporation of contamination prior to, during and following work.

5. RESULTS

External dosimetry

The result for actual collective dose was 4.388 mSv x p, as against the 6.085 mSv x p initially estimated. The maximum accumulated individual dose per day was 0.781 mSv.

Nº WAR	Task	Man-hours			Dose (uSv x M)		
		estimated	actual	%	estimated	actual	%
EJE-0052/101-99 (99155)	Conditioning of zones and assembly AES	240	303	126%	360	76	21%
EJE-0052/101-99 (99161)	Movement of materials from IFH roof and upper AES	105	362	345%	105	170	162%
EJE-0052/102-99 (99165)	Decont. And dismantling IFH cell equipment	1056	1643	156%	5620	4142	74%
TOTALES		1401	2308	165%	6085	4388	72%

* Total number of different operators intervening : 13

* RP technicians 3

* Maximum individual daily dose: 478 uSv

* Maximum total personal dose during work:	1079	uSv
* Average dose for intervening personnel:	511.5	uSv

Internal dosimetry

- Both the nasal smears and the internal contamination controls performed by the CRC have shown negative results. Furthermore, 71 bioanalyses were carried out on 35 people.

Radiological characterization of surfaces

Summary of characterization results:

- 83 points for the measurement of removable contamination.

  - Beta: 66 points < 0.04 Bq/cm^2 - 17 points > 0.04 Bq/cm^2
  - Alpha: 72 points < 0.4 Bq/cm^2 - 11 points > 0.4 Bq/cm^2

Wastes

- Compactable drums:	18
- Non-compactable drums :	11
- Shielded drums (filters) :	1
- CMT's:	12

Total masses:

- 13,710 kg of dismantled material (metallic, backfill, rubble).
- 666 kg of secondary wastes generated.

6. CONCLUSIONS

Regarding the achievement of objectives

- The levels of surface activity initially mapped out have been achieved. In most locations where the target values were not reached, an important reduction in activity values was achieved.

Regarding the efficiency of work techniques and resources used

- Following evaluation of the operational profitability of applying plasma cutting techniques, and their appropriate authorization on the basis of the results of tests performed for this purpose, it has been demonstrated that in practice the protection resources are adequate and the ventilation systems efficient. The effectiveness of these aggressive, but extraordinarily fast techniques makes it an interesting option and controllable from the radiological point of view, as long as the personnel involved is duly trained in its use.

- The use of peelable paints has been effective both for fixing of the existing surface contamination and for the protection of already decontaminated areas. There were no problems in their application and handling.

Regarding Radiological Protection

- The programs and procedures developed for control of the work and the scope of the generic and specific training (theoretical and practical) have been sufficient and adequate for the magnitude of the project.

- The technique of constructing and installing rigid AES's has been extraordinarily efficient as regards the confinement of contamination when working with important levels of depression with air renewal. The complete absence of releases of atmospheric contamination outside these AES's throughout the work demonstrate this.

- The resources, methods and routines for continuous radiological surveillance (continuous and periodic) of the working conditions and the workers themselves have been as complete as required by the characteristics of the project and have been reasonably useful and efficient.

- The personal and collective protection resources and equipment have been very efficient as regards the prevention of personal surface contamination.

- Evaluation of the effectiveness of the protection resources used against internal contamination (MAR – 95 and supply of external, filtered breathing air) has shown this system to be very acceptable for work of this type.

7. LESSONS LEARNED

- For work presenting radiological risks of the nature and level of those referred to in this article, or similar (significant levels of surface and atmospheric alpha contamination, the evolution of which may be affected by the characteristics of the work performed), it is necessary to implement technical means and resources reasonably ensuring the possibility of:

  - Conditioning personnel accesses and exits, with sufficient space for sequential dressing and undressing stages, with the corresponding step by step approach, allowing actions to be performed conveniently and safely. (These are the phases involving the highest radiological risk). In this same order of things, it is essential that there be rigorous individual discipline as regards the sequence of removing clothing, as a result of which the awareness of all the participating workers is especially relevant.

  - Obtaining and maintaining levels of air renewal and depression preventing or mitigating the inevitable variations in the concentration of atmospheric contamination in the work area, and especially at the personnel access and exit interfaces.

  - Obtaining and maintaining high levels of sealing, in order to minimize the risk of activity releases outside the Radiological Zone affected by the work.

  - Availability of personal protection equipment and systems (against surface and atmospheric contamination) offering a sufficient degree of protection regardless of the conditions in the work area.

- The main usefulness of controlling potential internal contamination (alpha) by means of nasal smears is that they allow large incorporations to be ruled out.

- The techniques and procedures authorized for work performance and the limits established must be in keeping with the level of demand regarding the objectives mapped out.

- The system used for the continuous surveillance of environmental contamination levels (alpha and beta), ABPM-302 beacons, has shown itself to be efficient both for the detection and measurement of values in real time and as an immediate alert system.

POOLS HALL – AIR SUPPLY LINE

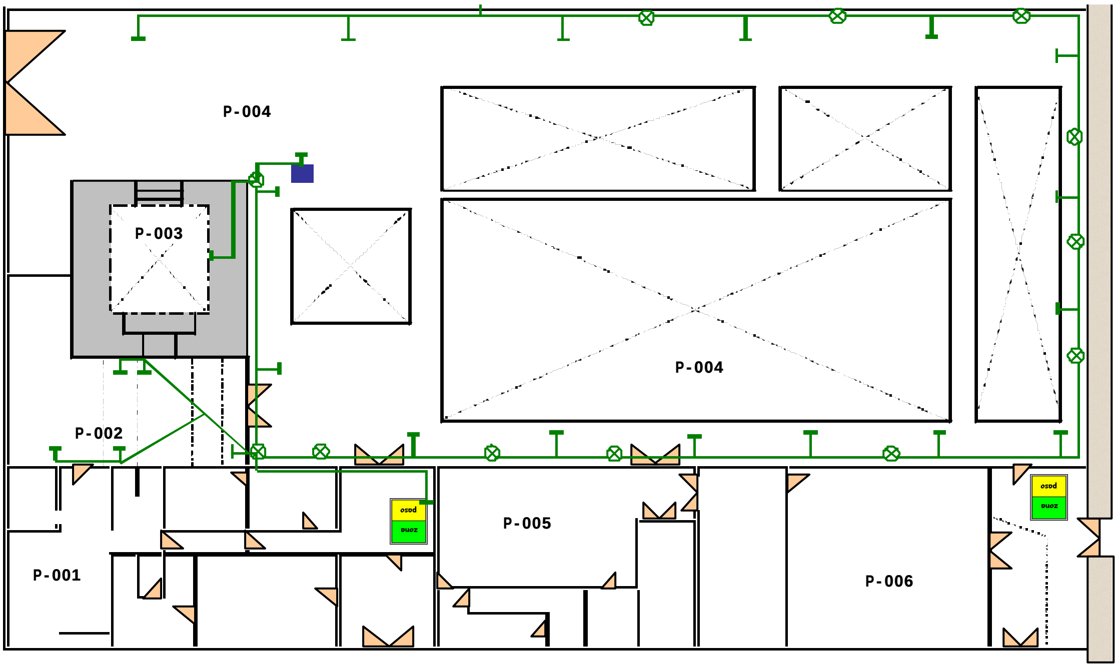

FIG. 1

PERSONNEL ROUTES AND AES LAYOUT

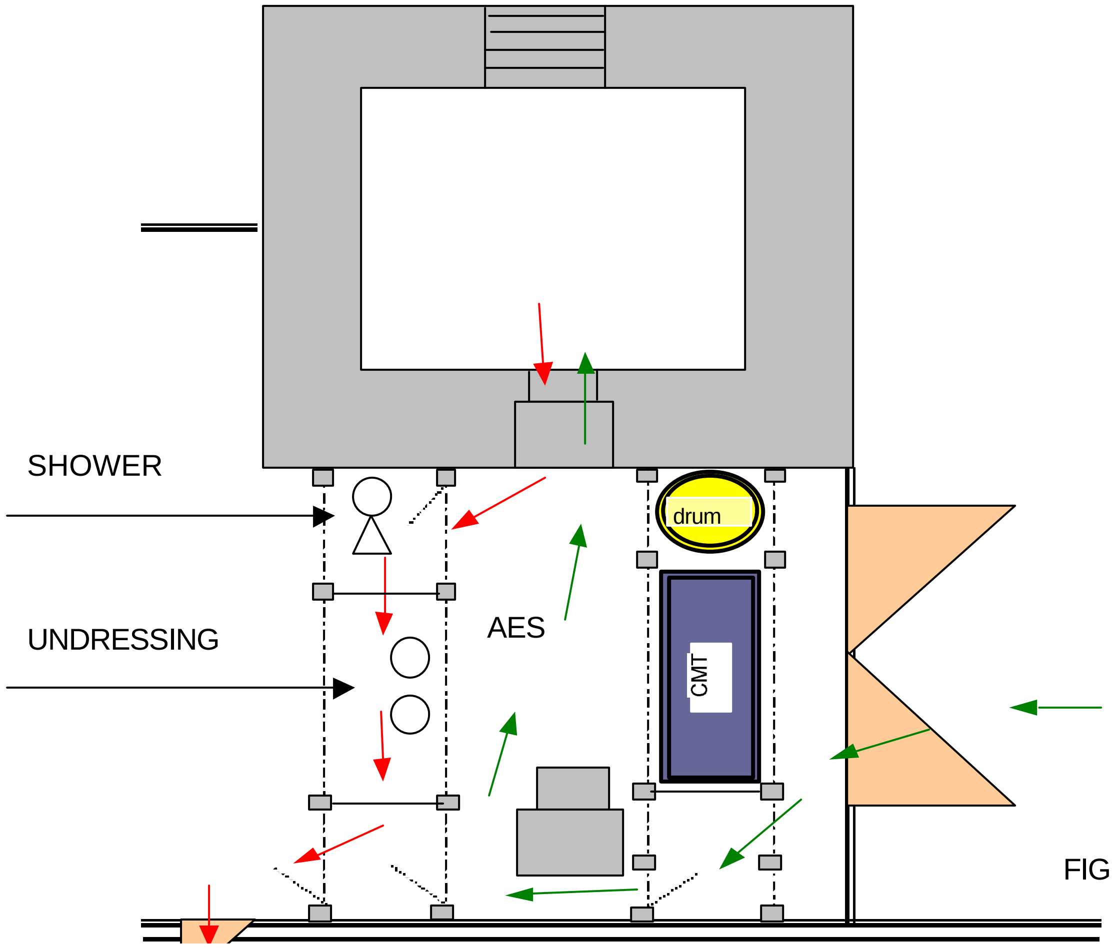

FIG. 2

PERSONAL PROTECTION EQUIPMENT

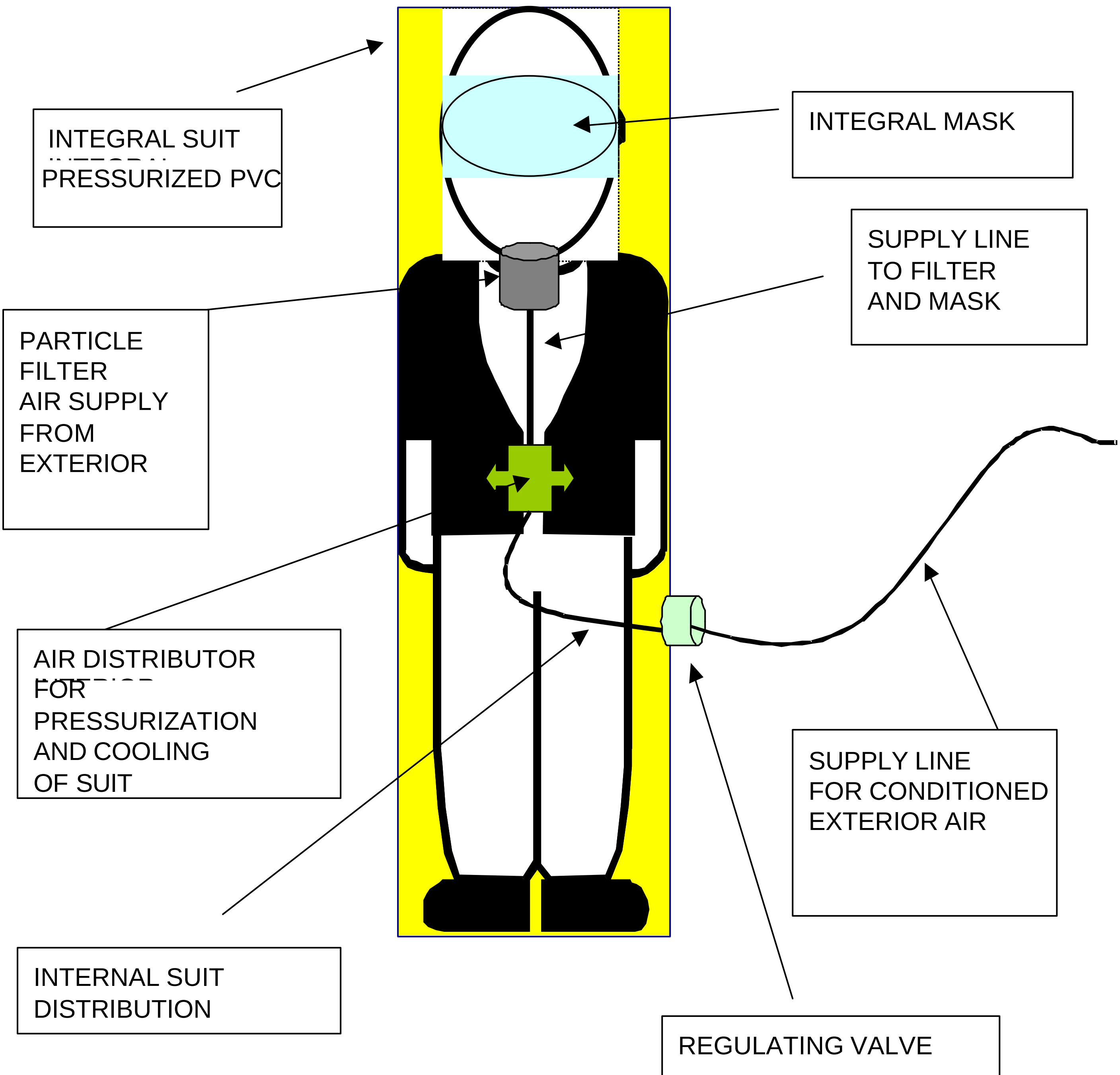

FIG. 3