PRACTICAL THRESHOLD LIMIT VALUES IN A CONVERSION PLANT

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Abstract

Comurhex is a subsidiary of the **Cogema** group, and its business is the conversion to hexafluoride of the uranium contained in a variety of mining concentrates of differing origins. This report gives an example of the evaluation of the health aspects of a conversion plant.

INTRODUCTION

The company has two production units: its **Malvési Works**, which produces uranium tetrafluoride, UF_4, and its **Pierrelatte Works**, where the tetrafluoride is converted to the hexafluoride, UF_6.

The end-product, the hexafluoride, subsequently goes to enrichment plants in which the proportion of the uranium-235 isotope is stepped-up by the gaseous diffusion or centrifuging processes.

MALVESI

The process and-the installations operated at Comurhex's Malvési Works are illustrated diagrammatically in Figure 1.

1. Digestion

The incoming ore concentrates (containing some 70 - 75% uranium) are digested in concentrated nitric acid. After a "maturing" period designed to assist the flocculation of insolubles (silica et al), if any, the liquor so obtained, containing some 650 grams of uranium per litre is filtered through a set of three back-washed rotary vacuum filters precoated with diatomaceous earth.

This yields a filtrate consisting of an impure solution of uranyl nitrate containing 450g uranium per litre (450g U/l). The insolubles filtered off, still containing traces of uranium, go to the Recovery plant (cf. 5 below) and thence to the waste lagoons.

2. Purification

The uranyl nitrate solution leaving the filters is purified by a two-stage liquid/liquid extraction process. In the first stage, the aqueous uranyl nitrate solution is intimately mixed, in a stirred column, with a solution of tributylphosphate (TBP) in dodecane. At the interfaces between the droplets of aqueous and organic phases the uranyl nitrate and TBP react to form a complex which passes into the dodecane phase.

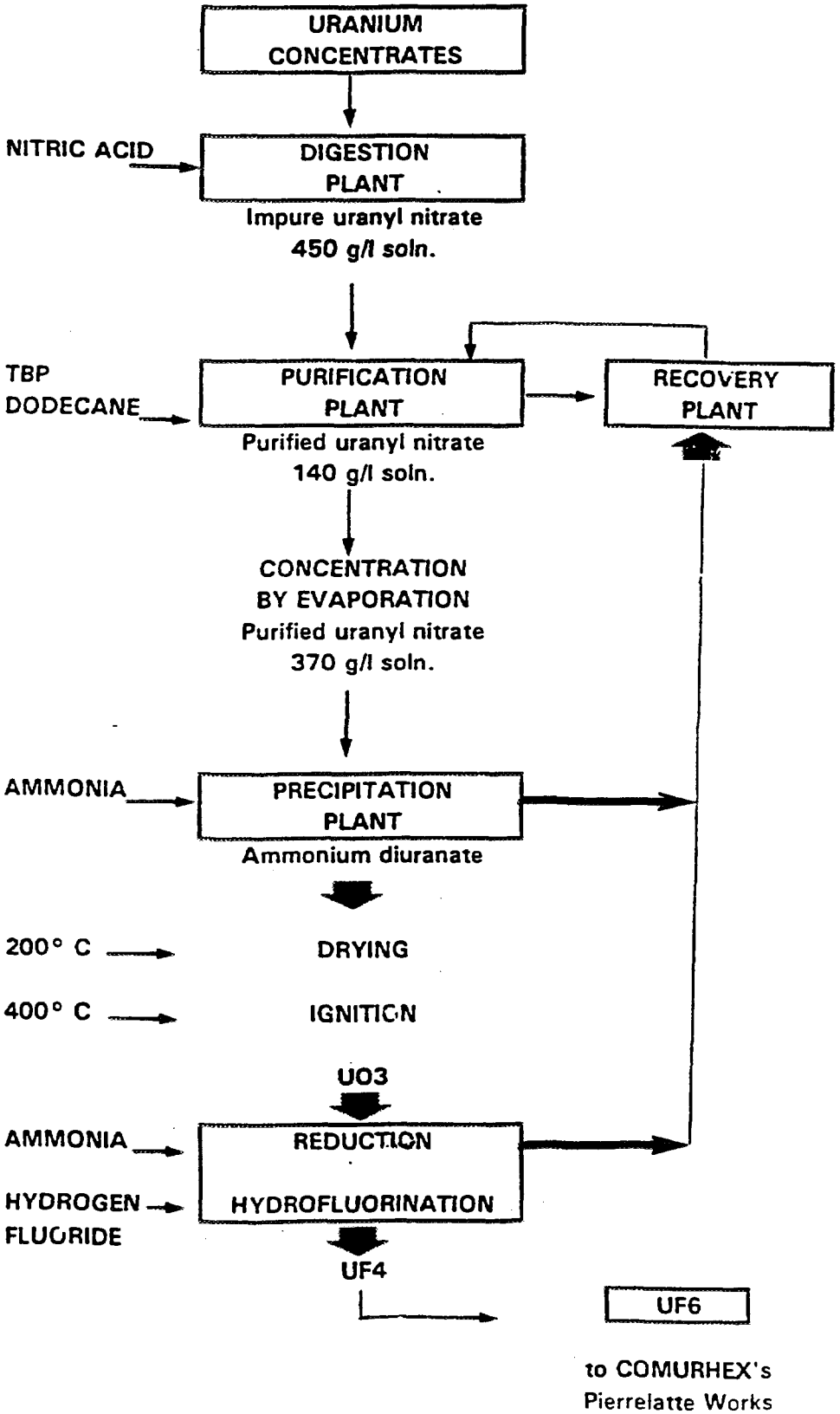


FIG. 1. Process and installations operated at the Comurhex Malvési Works

The organic phase, now loaded with uranium, is washed and the uranyl nitrate finally taken back into aqueous solution with demineralised water in a re-extraction column.

The solvent freed of uranium is regenerated and recycled to the extraction stage, while impurities, which contain less than 10 mg U/l, go, via the Recovery plant and after neutralization, to the lagoons.

The pure uranium nitrate solution, leaving the purification plant at a strength of 135 - 140g U/l, now goes to a four-stage steam-heated evaporator in which it is concentrated to a final 370g U/litre.

3. Precipitation and ignition

The next stage is to treat the uranyl nitrate solution with gaseous ammonia to precipitate the uranium as the diuranate.

The slurry so obtained is dewatered by rotary vacuum filtration and the ammonium nitrate mother liquor analysed and subsequently reused.

The ammonium diuranate (ADU) filter-cake is conveyed directly to calciners in which it is first dried, then ignited at some 400°C to obtain uranium trioxide, UO_3.

4. Hydrofluorination

The orange-coloured trioxide now goes to the Hydrofluorination plant, where it is first reduced to the brown dioxide, UO_2, and then reacted with hydrogen fluoride, HF, to obtain the tetrafluoride.

Both these operations are carried out in one and the same moving-bed furnace, in which the bed of solid material flows downwards. Gaseous ammonia injected into the upper part of the furnace is thermally cracked by heating to 700°C; the hydrogen so produced reduces the uranium trioxide to the dioxide and the dioxide finally reacts with hydrogen fluoride injected at the base of the furnace to yield the green tetrafluoride.

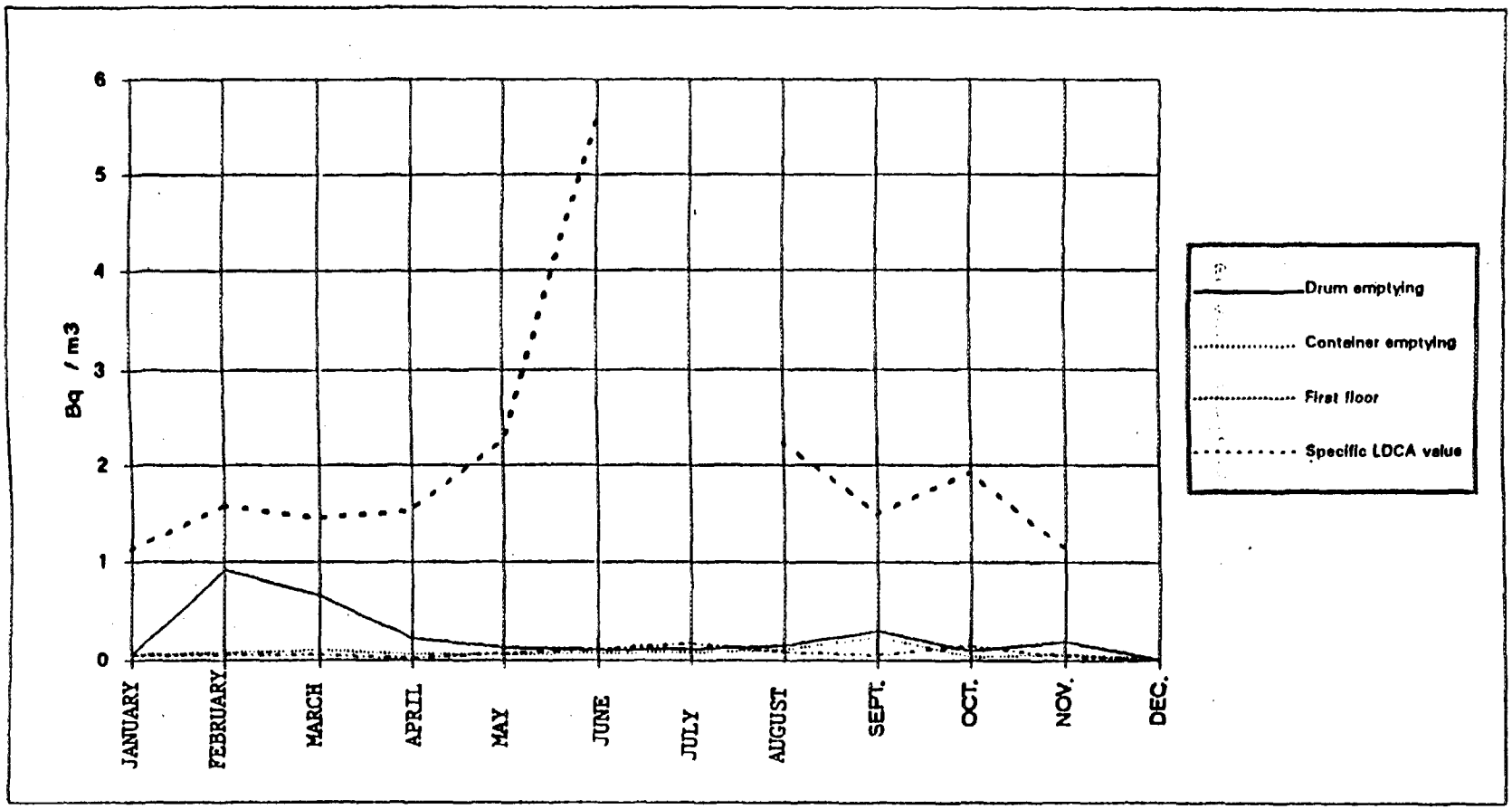
The uranium tetrafluoride leaving the furnace goes to a storage bin, from which it is loaded into road-tankers for delivery to Comurhex's Pierrelatte Works.

5. Recovery

All uranium-containing by-products of this conversion process are taken from the various production plants to a Recovery plant in which they are processed for complete recovery of uranium contents.

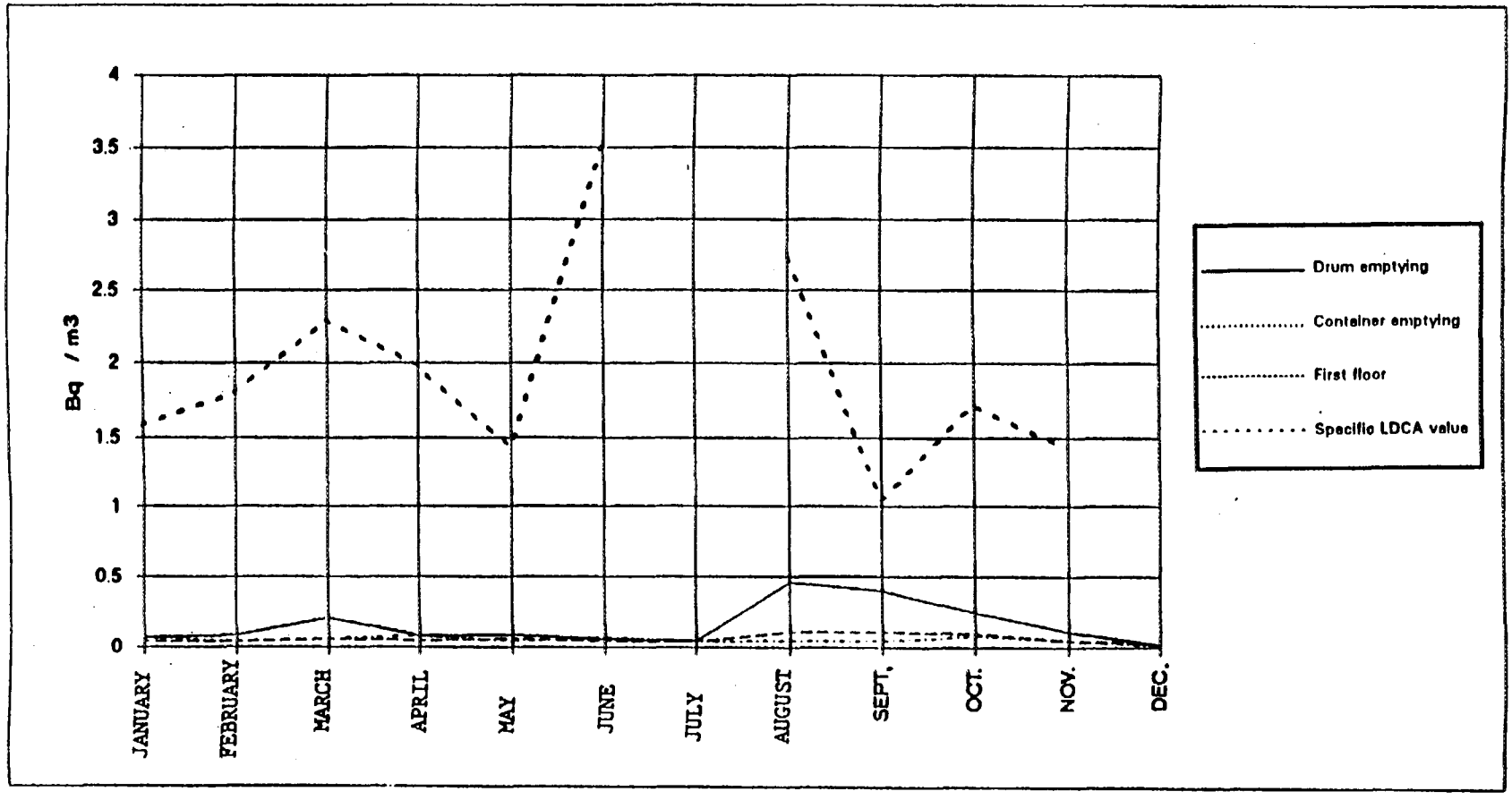
All the uranium thus recovered is recycled to the Purification stage. Residual uranium free liquors are neutralized with lime before going to the lagoons.

The Recovery plant also processes solid residues originating from Comurhex's Pierrelatte Works and from a number of COGEMA plants.



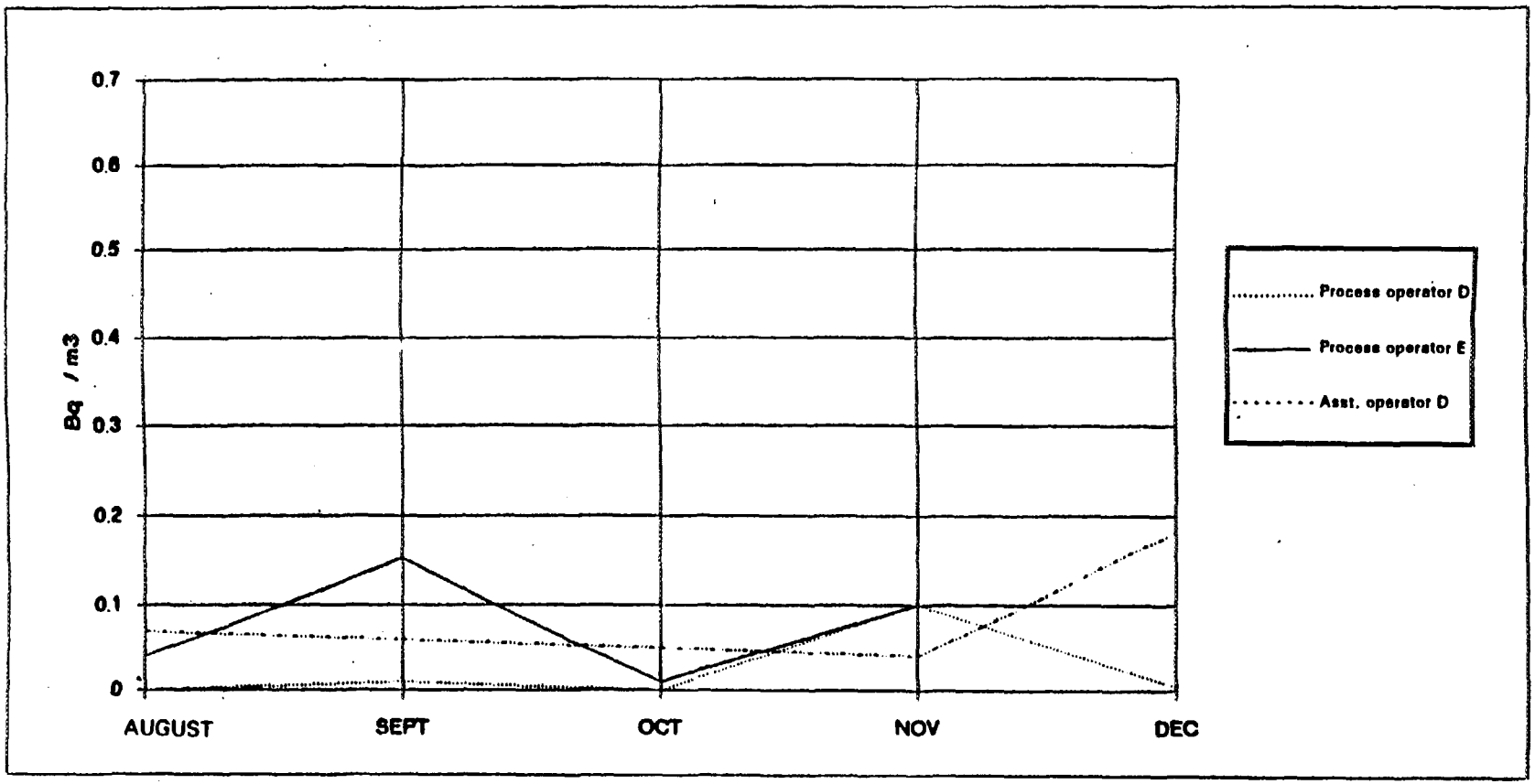
	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Drum emptying	0.06	0.92	0.68	0.23	0.14	0.11	0.12	0.16	0.31	0.1	0.2	0.02
Container emptying	0.06	0.09	0.11	0.07	0.07	0.08	0.09	0.11	0.25	0.04	0.07	0.02
First floor	0.05	0.06	0.06	0.03	0.08	0.12	0.18	0.09	0.06	0.16	0.04	0.01
Specific LDCA value	1.12	1.59	1.46	1.54	2.25	5.57		2.24	1.5	1.93	1.13	

FIG. 2a. *Digestion Plant - Atmospheric monitoring by aerosol samplers*
Monthly averages for 1992



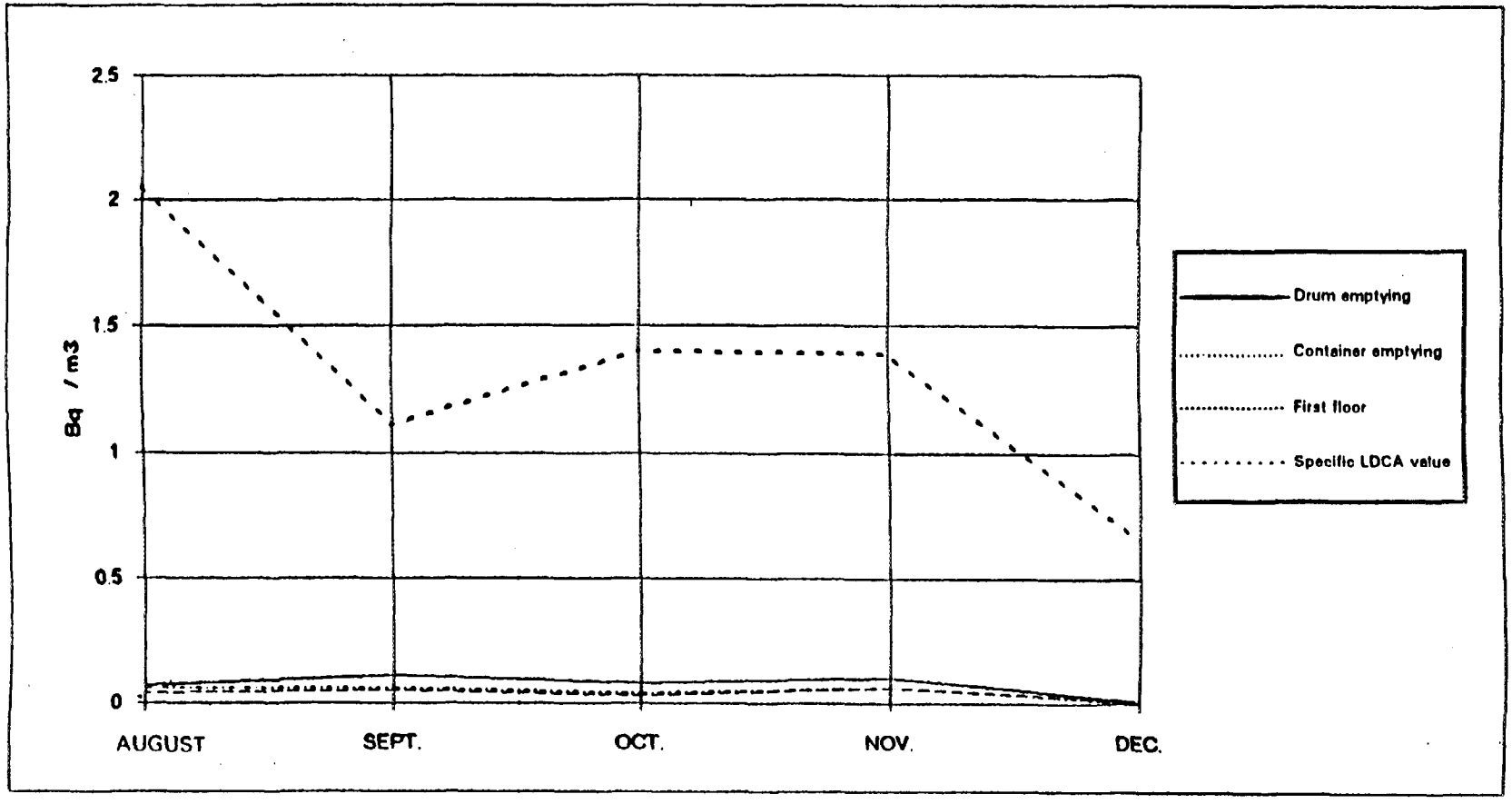
	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Drum emptying	0.07	0.09	0.21	0.08	0.09	0.06	0.05	0.46	0.4	0.25	0.11	0.02
Container emptying	0.04	0.04	0.06	0.05	0.06	0.04	0.04	0.11	0.11	0.1	0.05	0.03
First floor	0.07	0.04	0.06	0.08	0.04	0.07	0.04	0.05	0.05	0.08	0.05	0.02
Specific LDCA value	1.58	1.8	2.29	1.98	1.43	3.5		2.72	1.05	1.72	1.42	

FIG. 2b. *Digestion Plant - Atmospheric monitoring by aerosol samplers*
Monthly averages for 1991



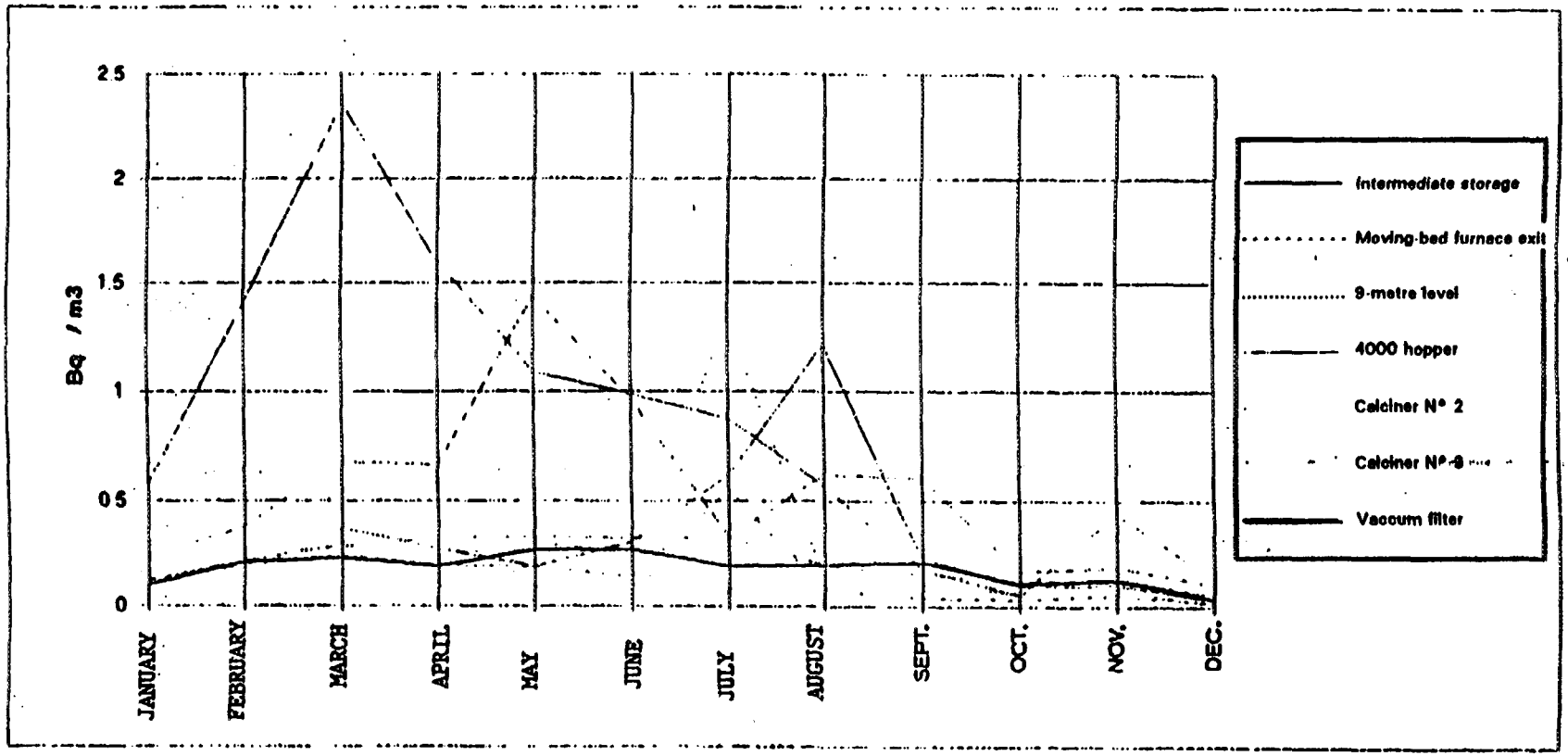
	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Process operator D	0.00	0.01	0.00	0.10	0.005
Process operator E	0.04	0.15	0.01	0.10	
Asst. operator D	0.07	0.06	0.05	0.04	0.18

FIG. 3. SIDI data for 1990



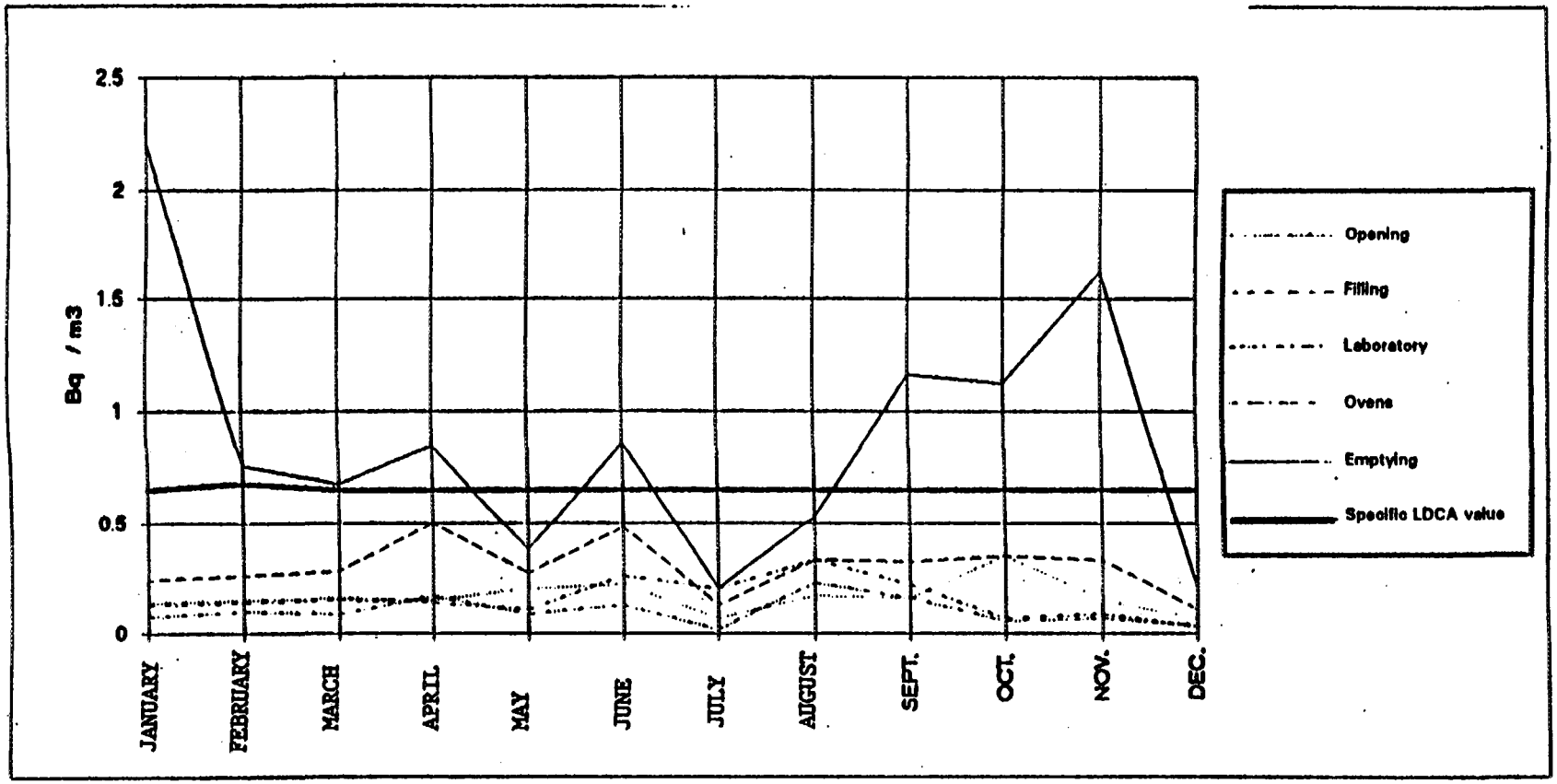
	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Drum emptying	0.07	0.11	0.08	0.10	0.007
Container emptying	0.06	0.06	0.04	0.06	0.003
First floor	0.04	0.05	0.03	0.06	0.005
Specific LDCA value	2.05	1.11	1.40	1.39	0.65

FIG. 4. *Digestion Plant - Atmospheric monitoring by aerosol samplers Monthly averages for 1990*



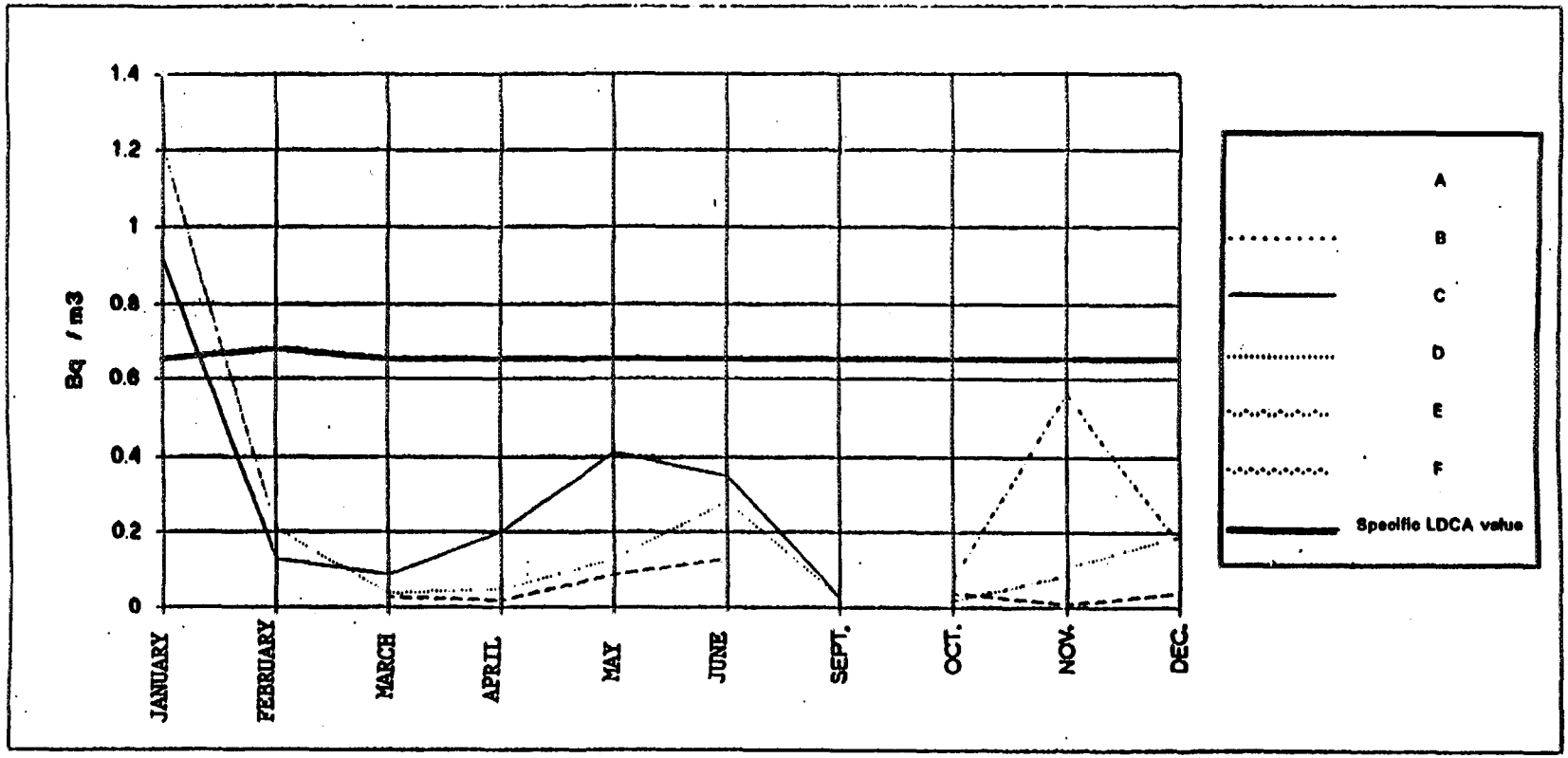
	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Intermediate storage	0.68	1.40	2.36	1.69	1.09	0.99	0.88	0.57	0.17	0.05	0.44	0.12
Moving-bed furnace exit	0.12	0.19	0.23	0.19	0.18	0.13	0.55	0.07	0.04	0.03	0.05	0.02
9-metre level	0.20	0.23	0.28	0.23	0.30	0.24	1.32	0.13	0.10	0.06	0.07	0.01
4000 hopper			0.37	0.27	0.18	0.30	0.62	1.21	0.22	0.09	0.10	0.03
Calciner N° 2	0.11	0.21	0.28	0.32	0.33	0.32	0.32	0.19	0.15	0.11	0.11	0.05
Calciner N° 3	0.23	0.38	0.68	0.67	1.43	0.97	0.33	0.62	0.61	0.16	0.18	0.10
Vacuum filter	0.09	0.20	0.22	0.18	0.26	0.26	0.18	0.19	0.20	0.10	0.12	0.03

FIG. 5. *Precipitation and Hydrofluorination Section*
Atmospheric monitoring by aerosol samplers - Monthly averages for 1992



	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Opening	0.14	0.15	0.16	0.15	0.20	0.22	0.07	0.17	0.16	0.35	0.15	0.07
Filling	0.24	0.26	0.28	0.50	0.27	0.48	0.13	0.33	0.32	0.35	0.33	0.11
Laboratory	0.13	0.14	0.15	0.14	0.11	0.26	0.20	0.33	0.22	0.07	0.09	0.03
Ovens	0.08	0.10	0.09	0.17	0.09	0.13	0.02	0.23	0.16	0.06	0.07	0.04
Emptying	2.20	0.76	0.68	0.85	0.38	0.86	0.20	0.53	1.16	1.12	1.62	0.20
Specific LDCA value	0.65	0.68	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.68

FIG. 6. *Sampling Station*
Atmospheric monitoring by aerosol samplers - Monthly averages for 1992



	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
A	0.		0.27							0.03
B	0.83		0.03	0.02	0.05	0.13		0.04	0.01	0.04
C	0.92	0.13	0.09	0.20	0.41	0.35	0.03			
D	1.21	0.21	0.04	0.05	0.13	0.28	0.03		0.11	0.19
E								0.02	0.09	
F								0.08	0.56	0.17
Specific LDCA value	0.65	0.68	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65

FIG. 7. Sampling Station - SIDI data 1992

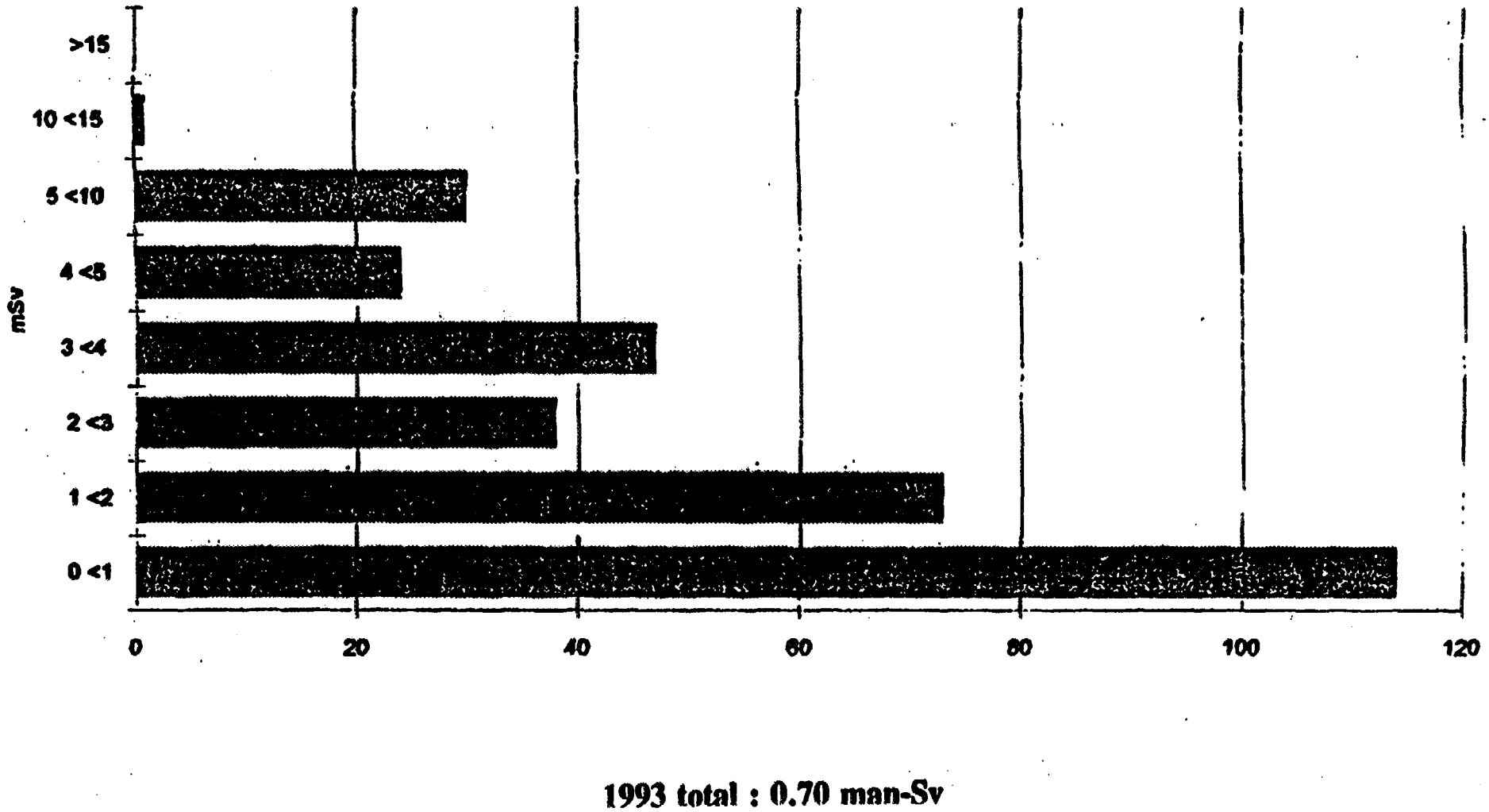


FIG. 8. *Comurhex - Malvési Works*
Potential individual exposures - 1993 : 327 people monitored

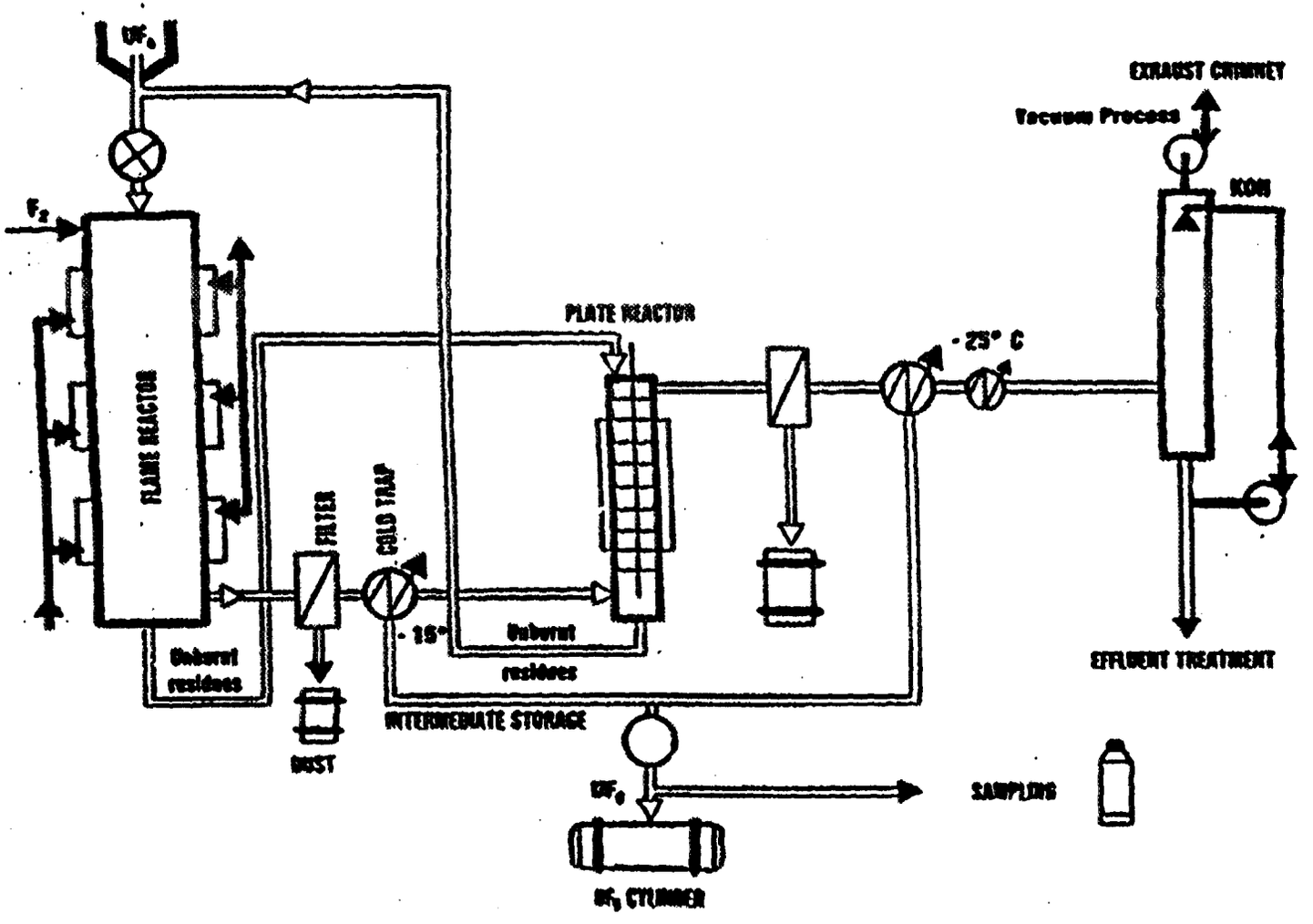


FIG. 9. *UF_4 Fluorination*

PIERRELATTE

The process of fluorination of natural uranium tetrafluoride (UF_4) carried on in the flurorination plant is detailed in Figure 9.

The tetrafluoride brought up by road-tanker from Malvési to Pierrelatte is conducted by pneumatic conveyor to storage bins.

A pneumatic conveyance system is also employed to feed the flame reactors in which the UF_4 is fluorinated. The reaction is highly exothermic, requiring the reactors to be cooled, and the reaction product, uranium hexafluoride (UF_6), is collected in traps cooled to -15°C. Unreacted materiai and reaction residues are recycled to the reactor inlets, while excess fluorine is burned off in a plate reactor fed with UF_4 and unreacted material.

The entire process is operated under vacuum so as not to endanger the environment, any leakage automatically resulting in ingress of air which is readily detectable by pressure monitoring in association with gas-chromatographic analysis.

Only the liquid UF_6 line from cold traps to containers is pressurised, environmental protection being here assured by the full and complete confinement of this circuit.

The system of supervision operated in the various parts of the Works will be described in due course.

SURVEILLANCE OF PEOPLE AT WORK

Next, to list the means employed in surveillance, both of the worker and of the workstation.

Now, we are concerned here only with radiological protection monitoring and not with other physical, or chemical, hazards to which personnel may be exposed, as exemplified, for instance, by hydrogen fluoride or ammonia, two chemicals employed in quantity at Malvési.

Radiological protection is based on the health physics principles enunciated by the International Commission on Radiological Protection (ICRP), i.e.

- the need to justify the use of ionising radiation when weighed against its potentially damaging radiological implications;
- the need to optimise means of radiological protection, based on the ALARA concept, to ensure that doses or probabilities of exposure are as low as possible for a given set of technical and economic imperatives;
- the need to limit individual doses and risks.

However, as we shall see in a moment, the ICRP 60 guidelines broaden the field as previousiy established and will be requiring us to make certain changes.

Two aspects have to be considered - workstations and workers - and the means employed are several.

A. Surveillance of workstations and of working environments

Surveillance of workstations and working environments means monitoring potential external exposure and potential internal exposure at the workstation considered.

A.1 Malvési Works

Surveillance of exposure to ambient external radiation is warranted only at very few points in Malvési Works, given that natural uranium is only a very weak gamma-emitter, and is exercised by means of three fixed γ-alarm monitors positioned at key locations.

Potential internal exposure by inhalation of uranium dust is monitored by means of aerosol samplers which continuously monitor atmospheric contamination in the various plants and shops making up the Works.

Twenty-five aerosol samplers strategically positioned throughout the Works, at points of maximum exposure, each draw-in air at the rate of 1.25 cubic metres per hour, an intake corresponding to the typical respiratory pattern of a man at work. They are fitted with 140 mm diameter filters which are checked daily for alpha- and beta-emission.

The results of these daily checks are compared with limits of concentration in air (LDCA[1] values) calculated from annual incorporation limits (AILs). The LDCA value is defined as the concentration (expressed as Bq/m^3) of a radioelement in air which, if inhaled over the standard total of 2000 working hours, would result in an internal exposure equivalent to the AIL.

A.2 Pierrelatte Works

External exposure monitoring is warranted by the concentration, at specific points in the Works, of natural radionuclides resulting from mechanisms of selective fluorination and is carried out by means of fixed environmental monitors, in combination with weekly measurements of irradiation at points of movement of personnel.

Potential internal exposure by inhalation of uranium dust is monitored via a total of 37 aerosol samplers strategically positioned at points of maximum exposure throughout the Works and continuously monitoring atmospheric contamination in the various plants and workshops. Drawing-in air at the rate of 1.25 m^3 per hour, corresponding to the typical respiratory pattern of a man at work, these samplers are fitted with 140 mm diameter filters which are checked daily for α and β emission. The results of these daily checks are compared with limits of concentration in air (LDCA values) calculated from annual incorporation limits (AILs) (Figure 10).

The LDCA value is defined as the concentration (expressed as Bq/m^3) in air of a radioelement which, if obtaining over the standard total of 2000 manhours, would result in an internal exposure equivalent to the AIL.

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[1] Limites Dérivées de Concentration dans l'Air (calculated limiting values of atmospheric concentration).

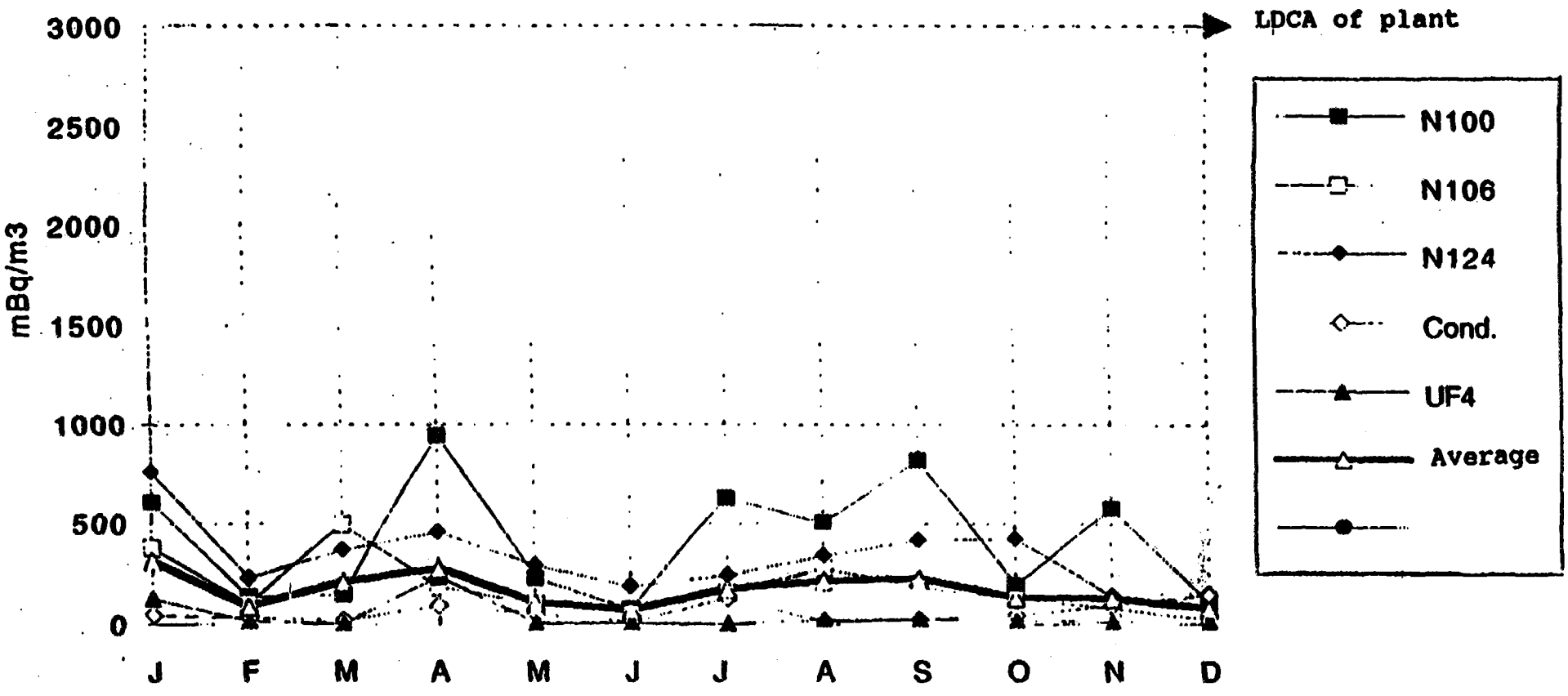

FIG. 10. *Fluorination Plant*
Atmospheric monitoring by aerosol samplers - Monthly averages for 1993

"Edgar" alarms are also employed for instantaneous atmospheric contamination monitoring, enabling the appropriate means of individual-operator radiation protection to be triggered if and when required.

B. Surveillance of the workforce

B.1 Malvési

The system comprises surveillance both of external exposure and of internal exposure.

External exposure is measured by means of individual monthly or three-monthly film badges, depending on personnel classification (A or B).

Internal exposure is monitored via determinations of uranium in urine and whole-body γ-measurements.

The workforce is monitored both for external and for internal exposures.

External exposure is measured by means of individual monthly film badges. Internal exposure is evaluated via (i) determinations of uranium in urine, (ii) whole-body gamma measurements and (iii) determinations of uranium in stools.

C. SIDI[2] system

Another, more particular, means of surveillance employed by Comurhex for certain members of the workforce is the SIDI system. This uses an individual air sampler associated with a measuring head; the monthly-based measurements comprise alpha counts on "long-life" radioactive aerosols and the detection of "short-life" alpha-emitter aerosols (incorporating radon decay products).

SETTING PRACTICAL TLV VALUES

Now to discuss how the overall system of surveillance is organized and how the TLVs adopted at Malvési have been determined.

Genuine and thorough familiarity with the processes employed, with process technologies and operating conditions, and with the precise activity engaged in (ergonomically speaking), is absolutely indispensable.

This is because we are dealing, not with conditions in the laboratory, but with industrial processes, i.e. where departures from ideal conditions and a variety of incidents can occur, with potential implications for process operation and, hence, the quality of the end-product: its chemical nature, particle size and content, if any, of impurities.

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[2] Système intégré de dosimétrie individuelle (integrated individual dose measuring system)

Also to be borne in mind is that any toxic chemicals present (e.g. gaseous ammonia or solvents) could compound the toxicity of uranium by modifying the body's natural clearance functions (renal and bronchial).

The three major parameters strongly influencing levels of retention/excretion of uranium are:

i) transferability (or solubility), as determined by the chemical nature of the substance concerned;
ii) particle size, as measured by median aerodynamic diameter (DAMA[3]);
iii) modes of contamination, i.e. acute or chronic.

The TLVs set in practice will, therefore, vary with conditions peculiar to particular parts of the Works.
Surveillance can be a relatively simple matter where all the people concerned always work in the same shop or plant and at identical workstations. Complications set in when they move around the Works (as in the case of supervisors, electricians, fitters, inspectors and the like).

There can therefore be no single, all-embracing, approach to surveillance, but only approaches specific to particular parts of the Works or, in some cases, to the person.

For each phase of the conversion process, therefore, the approach to surveillance and TLVs is determined on the basis of, and by reference to:

- complete familiarity with the process and process technology;
- the mode of contamination, acute or chronic, normal operating conditions being associated with low-level chronic contamination;
- theoretical knowledge of how the substance considered behaves in the organism (ICRP data);
  (Note: we are concerned here solely with natural uranium.)
- practical knowledge based on studies of workstations and physicochemical and biological data - the chemical nature of the uranium, concentration, impurities, hydration, particle size and solubility as determined by tests yielding reliable and readily reproducible results.
  (E.g.: technical uranium tetrafluoride is only some 95 - 96% pure and will contain impurities such as uranium dioxide and uranyl fluoride, UO_2F_2.)

Work has already been done in this connection at Malvési and the results of these studies are now of vital importance to health physics applied to the industrial environment.

ICRP 60 will mean applying an annual-exposure limit averaging 20 mSv over a period of five consecutive years, while not exceeding 50 mSv in any one year at Malvési.

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[3] Diamètre aérodynamique médian en activité (median aerodynamic diameter in activity)

In most of its installations, Comurhex are already operating at below this limit, which can however sometimes be approached if doses are estimated from the theoretical ICRP data (solubility /1μ particle size), whereas familiarity with the workstations and precise determination of the physicochemical characteristics of the substance or substances concerned yield lower estimates.

Let us take a typical case, on the basis of which to discuss, for the plant concerned, the system of surveillance operated and TLVs adopted, and then go on to consider particular features encountered in other sections of the Works.

1. The Digestion plant

The personnel working in it are specific to this section, which takes in concentrates of two kinds:

- oxides, featuring a DLCA value, for 1μ particle size, of 0.65 Bq α/m^3;
- uranates, featuring a 1μ DLCA of 20 Bq α/m^3.

Both the above types of concentrates will be being processed at any one time.

1.1 Chronic contamination scenario

AIL values specific to the plant are calculated once a month (by the officially prescribed procedure), based on uranate and uranium dioxide throughputs for the plant.

However, since these AIL values are, by definition, known only *a posteriori*, they obviously cannot be used to determine the alarm thresholds.

The thresholds for the Digestion plant have been established on the basis of the LDCA value for the oxides (0.65 Bq α/m^3 rather than for uranates.

The criteria adopted as indicating the need for remedial action are:

a) Any significant deviation from the normal operation of the plant, which has a total of four aerosol samplers variously positioned:

   at the drum-emptying station (working by suction), for which the TLV is 0.4 Bq α/m^3;
   at the container-emptying station,
   at the sampling station (since January 1993) and
   on the first floor, at the filters, for each of which the TLV is 0.2 Bq α/m^3.

b) Any steady drift in sampling results, even though the relevant alarm threshold may not actually have been reached.

   Monthly-average aerosol-sampling data for 1990, 1991 and 1992 are charted in Figure 2.

The medical alarm threshold has been set at 0.65 Bq α/m^3, i.e. at the LDCA for the oxides.

The SIDIs worn by certain members of personnel enable it to be checked that aerosol samplers have been correctly positioned in the plant, i.e. as near as possible to potential points of emission and therefore recording higher results than SIDIs (cf. Figures 3 and 4).

All personnel working on the Digestion plant are monitored via:

- their external exposure badge;
- regular determinations of uranium passed in urine;
- whole-body gamma measurements.

If the precise physicochemical characteristics of the uranium were known, the AIL value specific to the plant could be arrived at.

1.2 Potential acute contamination scenario:

Typical causes of acute contamination could be incidents such as spillage from an upset drum or leakage when uranium is being sucked from a drum or container.

The material could then be scattered around the Digestion section, but would consist only of a single type of concentrate, oxide or uranate, for which the theoretical LWA value is known, i.e.:

- 0.65 Bq α/m^3 tor oxides;
- 20 Bq α/m^3 for uranates.

Personnel would then apply the prescribed remedial procedure (including the use of special equipment) and be placed under medical supervision (initially involving determinations of uranium in urine).

OTHER SECTIONS OF THE WORKS

2. Purification

On this plant, operating the liquid-phase purification process, there is no exposure to dust. There could, however, be a risk of external exposure when working on raffinates, where deposits trapping thorium and protoactinium-234 collect.

Under normal operating conditions, the Purification section is no more than a walkthrough zone, containing no workstations as such.

A γ-radiation detector is located in proximity to the each raffinate and set to trip at 25 μGy/h, which corresponds to 50 mSv for a total of 2000 working hours.

If the measured value exceeds 5 mGy/h, entry into the zone is prohibited. If it lies between 25 μGy and 5 mGy/h, certain precautions have to be taken when carrying out remedial action (cleaning) and working time in the zone during the month is restricted so as not to exceed 2.5 mSv/month. This is an in-house rule at Malvési and equates to a maximum level of exposure of 2.5 x 11 (months) = 27.5 mSv/annum.

Note that the collective dose figure is unaffected by these calculations, which refer solely to a walk-through zone and not to a workstation.

3. Precipitation and Hydrofluorination

The people working on the Precipitation and Hydrofluorination plants are exposed to uranium trioxide and tetrafluoride dusts, two compounds theoretically classified "W".

Now, physicochemical investigation has established that their behavioral classification should in fact be closer to "D". The LDCA value is therefore 10 Bq α/m^3 in radiological terms, but the TLV applicable here has to do with chemical toxicity and is therefore lower, at 6.3 Bq α/m^3.

Technically-determined TLVs

There are seven monitoring points, variously employing:

3 aerosol samplers, with TLV set at 0.8 Bq α/m^3

Precipitation:	at the Calciner No. 2 exit
	at the Calciner No. 3 exit
Hydrofluorination:	at the point of intermediate storage.

4 aerosol samplers, with TLV set at 0.4 Bq α/m^3

Precipitation:	at vacuum filter No. 2
Hydronfluorination:	at the moving-bed furnace exit
	at the 4000 hopper
	at the 9 metre level.

(cf. Figure 5)

Medically determined TLVs

2.1 Bq α/m^3 (i.e. one-third of 6.3 Bq α/m^3).

Personnel working on these two plants are subject to surveillance via:

- external exposure badge;
- determinations of uranium excretion in urine.

4. Recovery

The approach applied on the Recovery plant is exactly as just described.

5. Sampling station

The Sampling station constitutes a special case by virtue of the particular features of the operating procedures employed (drum inversion and dust extraction at low vacuum to avoid modifying the characteristics of the material being sampled).

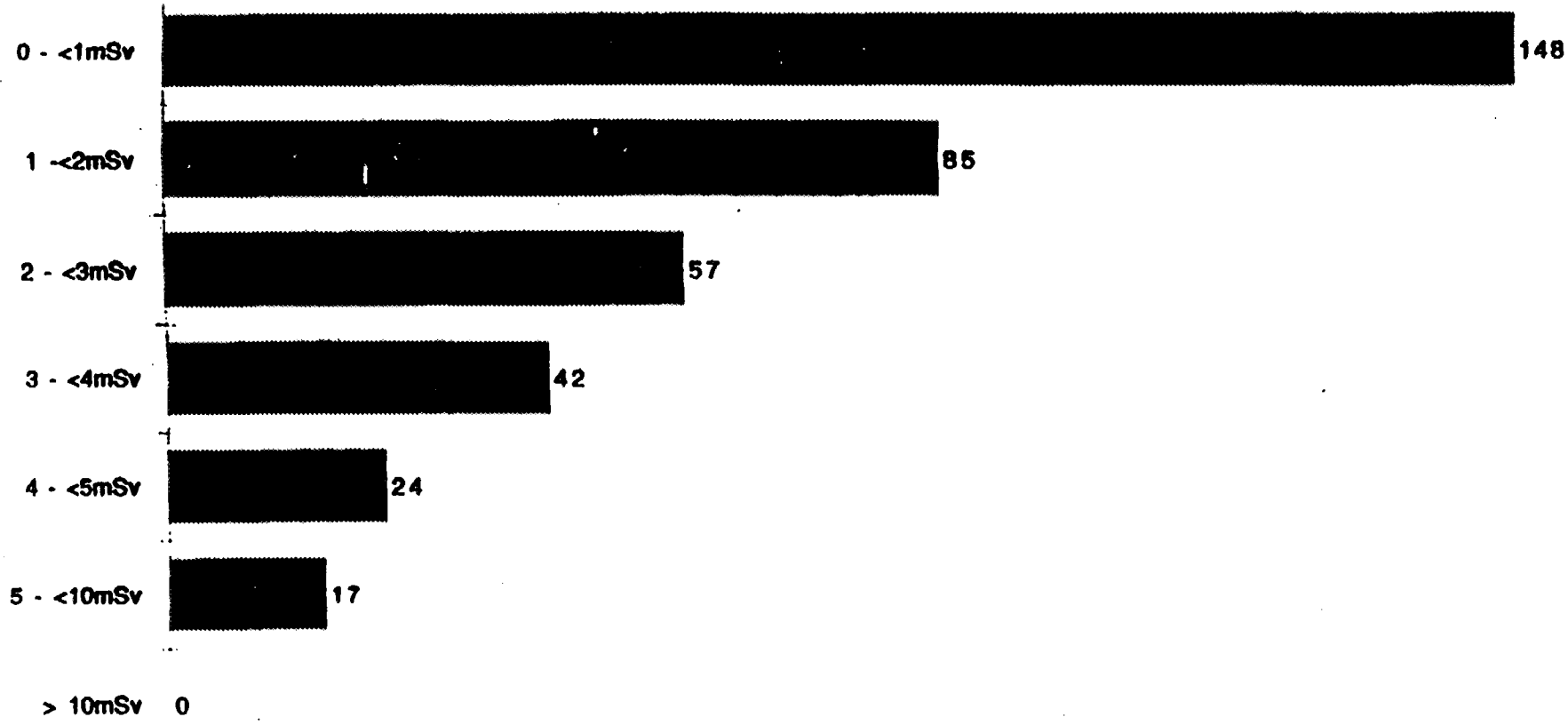

FIG. 11. *Comurhex -Pierrelatte Works*
Potential individual exposures - 1993 : 373 people monitored

The materials sampled are uranium oxide and uranates and the alarm threshold is 0.65 Bq α/m^3 (the LDCA for oxides).

The drum-inversion installation in the Sampling station generates dust at a rate oscillating about this alarm threshold and is so positioned that it contributes significantly to airborne dust in the shop as a whole.

It is planned to introduce a means of confinement of the drum-inversion installation in response to the CIPR's request that exposure be kept to the minimum reasonably achievable. This with a view to the new CIPR 60 standards of protection (20 mSv per annum over a 5- year period). (Cf.Figures 6 and 7.)

AT PIERRELATTE

The position in our Pierrelatte facilities is that, for all our personnel, we are well below half the proposed ICRP 60 limit.

Personnel performing more than one function move around the entire uranium sector with no compartmentation of process and other units.

Zones are defined according to the level of classification (monitored or controlled). Due account has to be taken of the LDCA of uranium tetrafluoride and, in order to allow for the presence of Category-B personnel, we have lowered the theoretical value from 10 to 3 Bq α/m^3.

The Edgar alarms monitoring instantaneous levels of atmospheric contamination alert personnel to the need to protect the respiratory tract (by donning masks).

The strategically positioned aerosol samplers enable the internal doses received by individuals to be evaluated (evaluations erring on the high side in taking no account of respiratory protection) (Figure 10).

Whenever any operation involving the opening-up of process plant or equipment is contemplated, a set of strict technical and medical procedures has to be observed:

- respiratory protection is obligatory and a radioprotection specialist or specialists must be present;
- radiotoxicological examinations of urine are mandatory.

ANNUAL RADIOLOGICAL PROTECTION PERFORMANCE

The bar-charts in Figures 8 and 11 record potential individual levels of exposure for Comurhex and contractors' personnel. Potential individual exposure is determined by summing external exposure and internal exposure evaluated from aerosol sampling data.

During the year 1992, 90% of personnel received less than 5 mSv per annum.

With a view to improved monitoring of installations and of the workforce and the future application of ICRP 60, a number of projects are currently being implemented:

- a real-time alarm monitor and preset TLV for major maintenance operations;
- computerization to improve the processing of aerosol sampling data;
- the use of a software package (LUDEP) affording good estimates of internal doses, and work on correlating estimates based on aerosol sampling data with the results of determinations of uranium in urine.

CONCLUSION

Aerosol samplers and Edgar alarms have a vital role to play in the monitoring of the various sections of the Works and, therefore, of personnel.

However, certain categories of personnel - supervisory personnel, electricians, fitters, inspectors and the like - are not fully covered by this mode of surveillance because they have to move about in the Works and because the nature of their duties can sometimes mean that they are more exposed than others. In their case, at Malvési, the SIDI system makes realistic assessments of exposures possible; all the same, the only means of determining their true level of exposure is by determinations of uranium in urine and whole-body gamma measurements.

Our concern has to be to bring the sum total of knowledge, resources and facilities to bear to minimise personnel exposure and also minimise margins of uncertainty affecting the evaluation of internal doses.

This can only be accomplished if we are aware of the precise physicochemical characteristics of the materials being dealt with.