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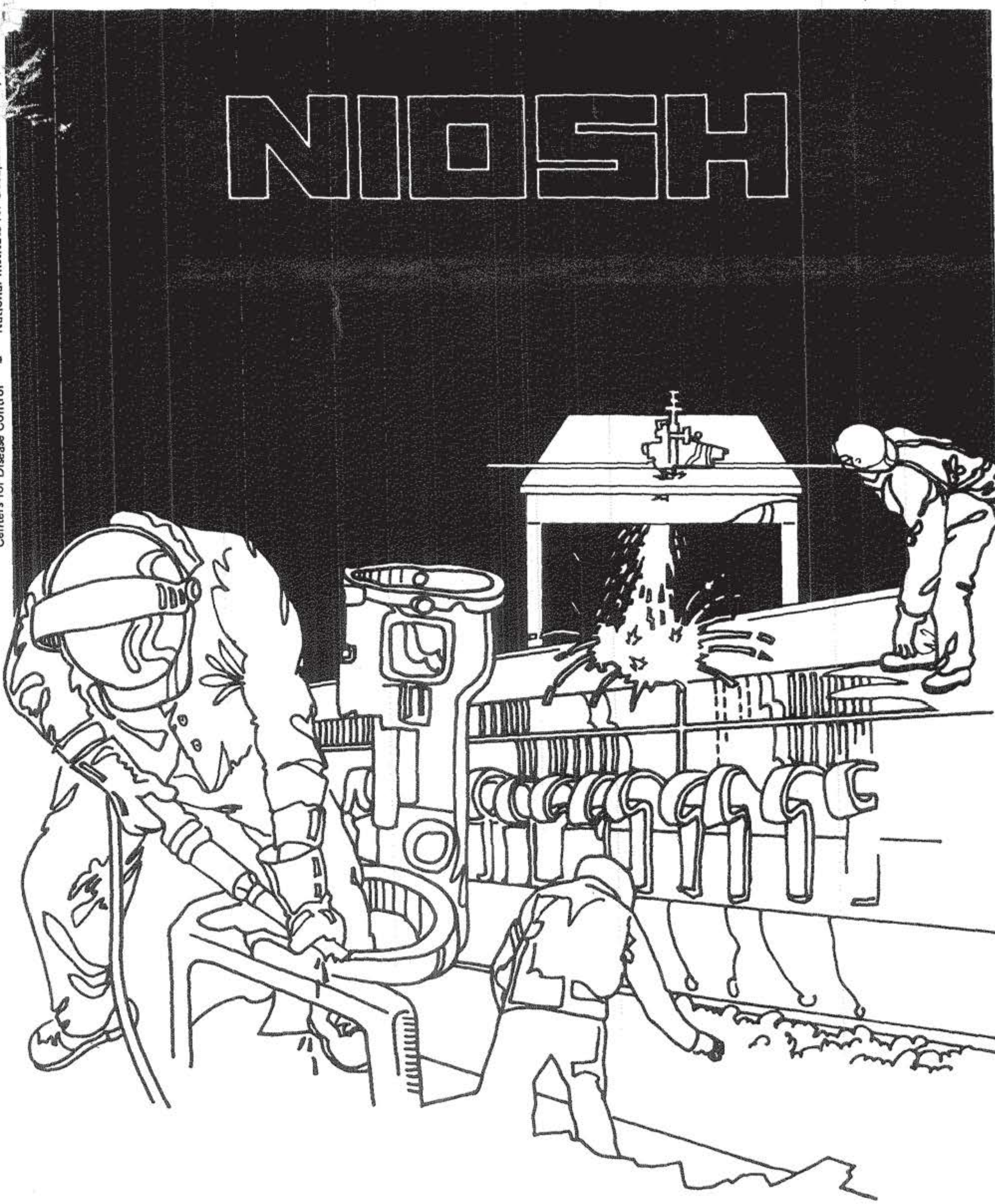

Health Hazard Evaluation Report

HETA 81-092-950
INTERNATIONAL PLAYTEX CORPORATION
NEWNAN, GEORGIA

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

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I. SUMMARY

On November 24, 1980, the National Institute for Occupational Safety and Health (NIOSH) received a written request to evaluate complaints of skin disorder, dizziness, stomach and breathing problems, and depression among employees working in a heat set molding operation of the International Playtex Corporation plant in Newnan, Georgia.

The health hazard evaluation was begun at the plant on February 18, 1981, by the University of North Carolina under a cooperative agreement with NIOSH. Seventeen molders and five punch press operators were evaluated by interviews and medical questionnaires. Punch press operators, who served as a control group, reported no acute respiratory symptoms associated with their work although two reported shortness of breath on exertion. In contrast, all molders reported symptoms of mucous membrane irritation while at work and a majority reported cough at work. Other symptoms reported by molders include headache, chest tightness, hoarseness, and shortness of breath. Two persons reported abatement of symptoms during absence from molding employment, then recurrence on return to molding. One mold worker reported loss of vision.

Molding fabrics were evaluated in the laboratory for emissions at molding temperature. Emissions to the air of materials other than moisture ranged from 0.9 to 5.3 mg/gram of fabric for various fabrics when they were heated to nominal molding temperature (205°C, 400°F). Pigmented fabrics, reported by molders to be most irritating, had the greatest emissions. Gas chromatography-mass spectrometry analysis of the molding temperature distillate from one fabric identified butyl esters of hexadecanoic and stearic acids, bis(p-aminophenyl)methane, and silicone compounds; the latter two are reported to be mucous membrane irritants. Gas chromatograms of molding temperature distillates of other fabrics showed peaks consistent with those of charcoal tube adsorption samples taken in the molding area during the field survey. Analysis of these field samples showed relatively low air concentrations of desorbates ranging from 0.01 ppm to 0.05 ppm for an average molecular weight of 350. Filter samples taken in the molding area showed particulate concentrations in air of 0.01 to 1.2 mg/m^3. Ventilation measurements made at the time of the field survey revealed imbalance between supply and exhaust air for the building.

On the basis of universal reporting of respiratory symptoms by molding machine operators and the demonstration of volatilization of about 1 to 5 mg/gram of fabric components, including mucous membrane irritants, when fabrics are heated to molding temperatures, it is concluded that the reported respiratory symptoms are work related. It is recommended that control measures to prevent inhalation exposures to mold process emissions be provided.

KEYWORDS: SIC 2342, heat set fabric molding, respiratory symptoms.

II. INTRODUCTION

On November 24, 1980, NIOSH received a request by three employees for a health hazard evaluation at the International Playtex Corporation plant (SIC 2342) in Newnan, Georgia. The request states that some of the Playtex employees who worked in the 'molding room' had complained of skin disorders, dizziness, stomach and breathing problems and depression which they believed were caused by the chemicals released when synthetic fabric is heated in molds. One person also reported loss of vision which she believes to be associated with environmental conditions at the plant.

III. BACKGROUND

The health hazard evaluation was begun at the plant on February 18, 1981, by the Occupational Health Studies Group, University of North Carolina, Chapel Hill, North Carolina, under a cooperative agreement with, and as a representative of, NIOSH. An interim report of initial survey activities and findings to that date was submitted in March, 1981.

The molding room operation normally employs 13 mold machine operators, 10 punch press operators, 7 service employees and one supervisor on the first shift. A smaller number of employees work on the second shift. The 29 molding machines (13 in pairs and 3 singles) and 10 punch press cutting machines are located in a space having approximately 6,000 sq. ft. of floor area and a 15 ft. ceiling. This space is part of a larger space comprising most of a manufacturing-warehouse building of some 65,000 sq. ft. floor area.

IV. METHODS AND MATERIALS

An initial environmental survey and medical interviews were conducted on February 18, 1981, by NIOSH representatives from the University of North Carolina and NIOSH Region IV personnel. Twenty-two employees were interviewed by the physicians and area and personal air samples were collected in the molding room for a determination of particulate and organic vapor concentrations. Ventilation measurements were made at several locations in the building. Direct reading detector tubes were used to determine whether formaldehyde was present in the air. Samples of fabrics used in the molding process, and both concentrated and diluted bulk samples of liquid adhesive, were collected for possible laboratory evaluation. Information was obtained from the company regarding the fabrics, adhesive, and operational procedures. A closing conference was held with management personnel to discuss the nature and scope of the NIOSH evaluation, to review questionnaire findings, and to offer suggestions for improving working conditions as observed during the one day of evaluation.

The two-part health status questionnaire (Health Screening History, Respiratory History) completed by the employees who were interviewed appears in Appendix A.

A variety of laboratory analyses have been done on specimens of fabrics used in molding operations to characterize materials which can be volatilized at molding temperatures. Air samples obtained at the time of the initial survey have also been analyzed.

Thermo-Gravimetric Analysis:

Thermo-gravimetric analysis (TGA) was performed on specimens of the following listed eight molding fabrics:

Code	Description
F28-167	White polyester - lycra 21% ± 3% lycra (polyurethane)
S28-167	Beige polyester - lycra 21% ± 3% lycra (polyurethane)
C28-388	Black polyester
F28-388	White polyester
X28-388	Dark beige polyester
F28-608	White polyester - lycra 12% ± 3% lycra (polyurethane)
S28-608	Beige polyester - lycra 12% ± 3% lycra (polyurethane)
127	White laminated polyester

Thermo-gravimetric analysis apparatus consists of a sensitive mass balance enclosed in a furnace which is capable of programmed temperature increase. The weight of a specimen on the balance decreases as material vaporizes from it with increasing temperature. Graphic traces of specimen mass vs. temperature for the fabrics listed above were obtained for the temperature range 30°C to 215°C (86°F to 420°F). The rate of temperature increase was 30°C per minute, the maximum rate of the TGA apparatus.

Tube Furnace Distillation:

In order to determine compounds that might be volatilized from the molding fabrics during the process of heat molding, various fabric samples were heated at nominal molding temperature (400°F, 205°C), in a tube furnace under a slow nitrogen purge. The purge gas was directed through a trap maintained at -78°C in an acetone-dry ice bath. Material from the cold trap and condensate in the distillation tube immediately downstream from the furnace were analyzed. Chromatograms of material from condensate and traps were qualitatively similar, with the shorter retention time peaks relatively more prominent in the cold trap samples.

Fabrics examined by tube furnace condensate analysis were:

Code	Description
S28-167	Beige, 79% polyester, 21% lycra
C28-388	Black, 100% polyester
F28-388	White, 100% polyester
127	White, laminated, 100% polyester

Gas Chromatography:

Chromatographic analysis of tube furnace condensate and field samples was done on an SE 30 column, 1/8" X 20', with temperature programming from 90°C to 175°C and with a flame ionization detector.

Highly polar compounds, such as amides, amines (classes of compounds employed as UV absorbers and anti-oxidants) and carboxylic acids (polyester monomer) would not be efficiently desorbed from charcoal and might not therefore be detected in the chromatograms from the field samples. As a control, a charcoal tube was used to sample one tube furnace run of one fabric (S28-167). The chromatogram of the desorbate appeared to contain fewer components than the distillation tube condensate.

Mass Spectrometry:

Fabric S28-167 was selected for analysis by gas chromatography-mass spectrometry (GC-MS) because of a consensus that more complaints had been associated with the molding of this fabric than the other fabric samples provided. GC-MS analysis was performed on condensate washed from the distillation tube of the tube furnace since analytical samples of this material could conveniently be obtained in high concentration to give optimal peak height/background ratio in the analysis.

Cyanide Determination:

Fabric S28-167, which contains polyurethane, was used to determine whether cyanide might be evolved when a specimen is heated to molding temperature. Cyanide determination was performed by bubbling tube furnace effluent through an impinger containing a 25 ml of 0.1N NaOH and analyzing the solution by selective ion electrode. (Method S250, Vol. 13, NIOSH Manual of Analytical Methods, 2nd ed).

Toluene Diisocyanate Determination:

Fabric S28-167, which contains polyurethane was used to determine whether toluene-2,4-diisocyanate (TDI) might be evolved when a specimen is heated to molding temperature. TDI was determined by sampling tube furnace effluent with a UEI Model 7000 TDI indicator.

Asbestos Determination:

Dispersion staining with polarized light was used to search for asbestos fibers in the insulation material. This optical microscopic technique identifies and/or quantitates asbestos fibers in samples.

Formaldehyde Determination:

Detector tubes were used to sample for formaldehyde in the general work area. The lower limit of detection for this method is approximately 1 ppm.

Field Sampling, Charcoal Tubes and Membrane Filters:

Vapor samples were adsorbed on charcoal and analyzed by means of gas chromatography upon elution by carbon disulfide.

Particulates were collected on 37 mm diameter Gelman Vinyl Metricel (VM filters) 5 m pore size taken in open face mode at sampling rates of about 1.7 liters/minute.

V. EVALUATION CRITERIA

Criteria for evaluation of health status are (a) comparison of results of Health Screening History and Respiratory History questionnaire responses of the exposed group of workers with those of a demographically similar group of workers who are not exposed, and (b) judgement of the examining physicians.

Environmental evaluation criteria are the American Conference of Governmental Industrial Hygienists Threshold Limit Values (ACGIH-TLV), the U.S. Department of Labor Occupational Health Standards (OSHA), NIOSH Criteria Documents, NIOSH Current Intelligence Bulletins, and the NIOSH Registry of Toxic Effects of Chemical Substances.

Substance	Ceiling Limit or Stel	8-hour Time Weighted Average	Source
Asbestos	LFL*	LFL	NIOSH (1)
Formaldehyde	LFL	LFL	NIOSH (2)
Hydrogen cyanide (skin)	10 ppm		ACGIH-TLV(3)/OSHA(4)
Toluene-2,4-diisocyanate	0.02 ppm	0.02 ppm	ACGIH-TLV(3)/OSHA(4)
TDI (Intended Change)	0.02 ppm	0.005 ppm	ACGIH-TLV(3)/OSHA(4)

*Lowest Feasible Limit (LFL)

Asbestos has been identified as a carcinogen (1), NIOSH has recently published a Current Intelligence Bulletin on evidence of carcinogenicity of formaldehyde (2). Safe levels of exposure to carcinogens have not been demonstrated, but the probability of developing cancer should be reduced by decreasing exposure. In the interim, NIOSH recommends that engineering controls and stringent work practices be employed to reduce occupational exposure to the lowest feasible limit (LFL).

Only a few compounds emitted by molding fabric S-28-167 at molding temperature have been identified. Although Threshold Limit Values or occupational health standards have not been established for those compounds identified, some toxicologic implications of exposures to them have been reported as follows(5):

n-Butyl stearate is reported to have low oral toxicity. No information on inhalation toxicity or potential irritant properties has been found. Other fatty acid esters would likewise be assumed to be of low order of toxicity and of no special significance as respiratory irritants.

Silicone compounds as a class are reported to have low oral toxicity and mild to moderate irritant effects by rabbit skin and eye tests.

Bis (p-aminophenyl) methane is reported to have low oral toxicity, however this compound may have irritant capability, since it is reported as an eye irritant in tests on rabbits. This compound is also being tested for carcinogenicity by NCI and has been reported to produce neoplasms in rats.

VI. RESULTS

Medical Inquiry:

Seventeen molders and five punch press operators were evaluated with medical questionnaires. The punch press operators worked an average of 15 to 20 feet from the molding machines. These operators reported no significant respiratory symptoms except for two who complained of shortness of breath on exertion. A number of the molders reported respiratory symptoms. Five of the molders reported chest tightness since beginning work in the molding operation. Five reported symptoms of chronic post-nasal drainage and two reported loss of sense of smell, again since beginning work in the molding operation. Two of the molders who smoke have developed symptoms of chronic bronchitis since working in the molding operation.

None of the punch press operators reported any acute respiratory symptoms associated with their work. In contrast all of the molders reported symptoms of mucous membrane irritation while at work. These symptoms were reported to appear primarily when working with pigmented fabrics. A majority of the molders also reported cough at work and one related her chest tightness to work exposures. Two individuals reported headaches related to work, one specifically relating it to working with fabric coated with adhesive. The molders who worked on the second shift had fewer symptoms and what symptoms they had were minor.

Two individuals were employed such that they worked during two different time intervals in the molding operation. One first worked in the molding area in 1977 as a laboratory technician. During this time she developed hoarseness. Between 1978 and May 1980, she worked as a molding machine operator. Her hoarseness continued and required in-hospital evaluation. Although an operation was performed, her symptoms continued. They completely abated during a five-month interval during which she was away from the molding area. They recurred in October of 1980 within a few days after she returned to the molding area and have continued to the present time. She also reported chest tightness and cough while in the molding area. The second person who reported interruption of work time in the molding area worked as a molding machine operator for a period of six months, was out of the work area for a period of time and then returned to the molding area in October of 1980. She also reported hoarseness which began when she was first working as a molding machine operator. Her hoarseness also cleared while away from the molding area only to recur when she returned to this area. She also reported chest tightness and shortness of breath since working in the molding machine area.

Another worker who developed shortness of breath, chest tightness and cough while working as a molding machine operator also reported loss of vision. Her respiratory symptoms completely cleared once she stopped work in January, 1980. Other than this one worker, no other worker had any significant complaint of loss of vision.

No reports were made of unusual occurrences of skin problems, dizziness, or depression related to work. A summary of worker reported symptoms appears in Table I.

Air Sampling and Molding Emissions:

The molding fabrics listed in Tables II & III were analyzed by thermo-gravimetric analysis (TGA) between the temperatures of 30^{o}C and 215^{o}C. TGA charts for the fabrics analyzed appear in Appendix B. From the individual TGA charts of weight loss vs. temperature, calculations were made for each fabric of weight loss in milligrams per gram of fabric. Table II shows this weight loss from 30^{o}C to 204^{o}C and 30^{o}C to 215^{o}C. The upper limit of the mold temperature for most of the fabrics is 215^{o}C (420^{o}F). The range of calculated weight loss for the fabrics analyzed is from 1.6 to 6.6 mg/g fabric. The rate of temperature increase was 30^{o}C per minute, so approximately 6 minutes were used to run each complete test. Actual molding time for the fabrics is much less than 6 minutes and they undergo a much more rapid increase in temperature. The molds generally operate in the range 375^{o}F to 420^{o}F. (190^{o}C to 215^{o}C).

Based on TGA laboratory data described above, estimates of emissions under actual working conditions can be made. Assume that each fabric to be molded is 10 or 12 inches square and weighs approximately 10 grams and that they are molded at a rate of four (two pair) per minute. According to laboratory observations, 40 grams of fabric being molded at 420^{o}F could release fumes, vapors, and/or gases from the fabric into the work room air at a rate of about 64 to 264 mg per minute. This rate of emission could be increased by a factor equal to the number of plies of fabric for multi-ply molded goods. Since as many as ten mold machines may operate at once, substantial amounts of molding emissions may be released in the molding work area.

Table 1

Summary of Worker Reported Symptoms, Heat Set Molders and Punch Operators. February 18, 1981 Interview and Questionnaires.

	Molders		Punch Press Operators	
	Smokers	Non-Smokers	Smokers	Non-Smokers
Total Number	6	11	3	2
Average Time on Job (Years)	2.3	2.6	3.7	3.8
Respiratory Symptoms, General				
Chest tightness	1	4	0	0
Post-nasal drainage	3	2	0	0
Dyspnea on exertion	3	2	1	1
Stuffy nose	5	2	1	1
Decreased smell sense	2	0	0	0
Treatment for acute bronchitis	3	2	0	0
Morning cough greater than 3 months/year	2	0	0	0
Phlegm greater than 3 months/year	2	1	0	0
Work Related Symptoms				
Nose irritation	5	8	0	0
Eye irritation	5	6	0	0
Throat irritation	3	4	0	0
Hoarseness	0	2	0	0
Chest tightness at work	0	1	0	0
Cough at work	4	8	0	0
Headache at work	2	0	0	0

Table II

Thermo-Gravimetric Analysis (TGA) Showing Weight Loss from 30°C to 204°C and 30°C to 215°C of Synthetic Fabrics
Range for molding temperatures, 190°C to 215°C (375°F to 420°F)

Fabric Number	Fabric Weight (%) at			Weight Loss, 30°C to 204°C		Weight Loss, 30°C to 215°C		Fabric and Process Information
	30°C	204°C	215°C	(%)	(mg/gm)	(%)	(mg/gm)	
F28-388	99.96	99.74	99.78	0.22	(2.2)	0.25	(2.5)	White, polyester
X28-388	99.96	99.64	99.59	0.32	(3.2)	0.37	(3.7)	Dark Beige, same as above
C28-388	99.99	99.40	99.33	0.59	(5.9)	0.66	(6.6)	Black, same as above
F28-167	99.94	99.81	99.78	0.13	(1.3)	0.16	(1.6)	White, polyester 21 ± 3% lycra
S28-167	99.83	99.69	99.64	0.14	(1.4)	0.19	(1.9)	Beige, same as above
F28-608	99.95	99.70	99.66	0.25	(2.5)	0.29	(2.9)	White, polyester 12 ± 3% lycra
S28-608	99.89	99.51	99.48	0.38	(3.8)	0.41	(4.1)	Beige, same as above
127	99.86	99.57	99.54	0.29	(2.9)	0.32	(3.2)	F28-126 & F28-476 White patterned (poly)

Note: 30°C = 86°F
204.4°C = 400°F
215.6°C = 420°F

Table III

Thermo-Gravimetric Analysis (TGA) Showing Weight Loss from 120°C to 204°C and 120°C to 215°C of Synthetic Fabrics
Range for molding temperatures, 190°C to 215°C (375°F to 420° F)

Fabric Number	Fabric Weight (%) at			Weight Loss, 120°C to 204°C		Weight Loss, 120°C to 215°C		Fabric and Process Information
	120°C	204°C	215°C	(%)	(mg/gm)	(%)	(mg/gm)	
F28-388	99.87	99.74	99.71	0.13	(1.3)	0.16	(1.6)	White, polyester
X28-388	99.84	99.64	99.59	0.20	(2.0)	0.25	(2.5)	Dark Beige, same as above
C28-388	99.86	99.40	99.33	0.46	(4.6)	0.53	(5.3)	Black, same as above
F28-167	99.87	99.81	99.78	0.06	(0.6)	0.09	(0.9)	White, polyester 21 ± 3% lycra
S28-167	99.75	99.69	99.64	0.06	(0.6)	0.11	(1.1)	Beige, same as above
F28-608	99.80	99.70	99.66	0.10	(1.0)	0.14	(1.4)	White, polyester 12 ± 3% lycra
S28-608	99.57	99.51	99.48	0.06	(0.6)	0.09	(0.9)	Beige, same as above
127	99.72	99.51	99.54	0.15	(1.5)	0.18	(1.8)	F28-126 & F28-476 White patterned (poly)

Note: 120°C = 248°F
204.4°C = 400°F
215.6°C = 420°F

Table III shows calculations based on similar considerations as above, except only weight loss above 120°C (248°F) is calculated. It is assumed that water adsorbed on the fabric will vaporize by the time the temperature reaches 120°C and that further weight loss will be due to vaporization of other chemical compounds. Based on the temperature range of 120°C to 215°C, the range of calculated weight loss for the fabrics analyzed is from 0.9 to 5.3 mg/g fabric. Again, assuming each fabric to be molded weighs 10 grams and that a total of 40 grams of fabric is molded per machine per minute, a molding machine could release 36 to 212 mg/minute of fumes, vapors and/or gases into the work area. Again the amount could be multiplied by a factor depending upon the number of plies required by the item being molded. Ten mold machines operating at the same time would increase by a factor of ten this estimated emission to the general work area.

In Table IV the fabrics have been listed in order of increasing weight loss (120°C to 215°C). Generally, the pigmented fabrics release a larger quantity of material during heating than the white or light beige fabrics. The presence of lycra appeared not to be a determining factor in the quantity or rate at which the heated fabric released volatile material. (See individual TGA graphs, Appendix B).

Because it was among the fabrics identified with respiratory irritation during molding operations, fabric S28-167 was selected for GC-MS analysis. The condensate from the distillation tube of the tube furnace operated at 205°C was analyzed. The chromatogram is presented in Figure 1 and component identification in Table V. The results of GC-MS analysis indicate that the major constituents of aerosols and vapors generated during molding probably arise through distillation of chemical compounds applied to the fibers during finishing. These compounds include lubricants, anti-oxidants and UV absorbers. Agents identified by mass spectrometry include bis (p-aminophenyl) methane, the butyl ester of hexadecanoic acid, n-butyl stearate, and silicone compounds. A listing of specific chemicals used to treat the molding fabrics was not available to verify the assignments in Table IV.

Gas chromatograms were obtained on distillate from tube furnace heating (205°C) of several other molding fabrics. None of the major components from S28-167 appeared to coincide with major components of other fabrics. White (F28-388), black (C28-388) and laminated white (F28-127) 100% polyester fabrics all appeared to have common components, within the range of reproducibility of retention times ($\pm$ 1 min).

Table IV

Synthetic fabrics in order of increasing weight loss in % and mg/g of fabric

Fabric Number and Type		Weight loss % (mg/g) 30°C to 215°C		120°C to 215°C	
F28-167	*White, 21 ± 3% lycra	0.16	(1.6)	0.09	(0.9)
S28-608	Beige, 12 ± 3% lycra	0.41	(4.1)	0.09	(0.9)
S28-167	*Beige, 21 ± 3% lycra	0.19	(1.9)	0.11	(1.1)
F28-608	White, 12 ± 3% lycra	0.29	(2.9)	0.14	(1.4)
F28-388	**White, 100% (no lycra)	0.25	(2.5)	0.16	(1.6)
127	White, patterned F28-126 (lace, laminated) and F28-476 (tricot)	0.32	(3.2)	0.18	(1.8)
X28-388	Dark beige, 12 ± 3% lycra	0.37	(3.7)	0.25	(2.5)
C28-388	Black, 12 ± 3% lycra	0.66	(6.6)	0.53	(5.3)

*40/27 Dacron, Type 56

**75 Denier Textured Polyester Dull

30°C = 86°F
120°C = 248°F
215°C = 420°F

Charcoal tube samples for adsorbable vapors were taken in the breathing zones of several molding machine operators. Of these, charcoal tubes #1001, 1005 did not contain sufficient sample for observable chromatograms although the total quantity of desorbable material could be estimated. Charcoal tubes #1000, 1002 and 1003 appear by chromatographic analysis to have two groups of components in common (retention times 22-23 min and 25-28 min). These peaks also occur in the chromatograms of the tube furnace condensates of the 100% polyester fabrics. Within the uncertainty limits of reproducibility of retention times, most of the peaks present in the charcoal tube desorbate correspond to peaks present in the tube furnace condensate from polyester fabrics. None of these peaks coincides with compounds identified in Table V for S28-167. Rigorous verification would require GC-MS analysis of the charcoal tube samples.

Although chromatographic analysis of all of the charcoal tube field samples was not practical, air concentrations of desorbable total vapors based on an average molecular weight of 350, were calculated. Low concentrations <0.01 to 0.05 ppm, were observed for the five charcoal tube samples taken. The concentrations for individual samples are shown in Table VI.

Membrane filter samples of air from the breathing zones of workers in the molding room and near molding machines showed total particulate concentrations between 0.10 and 1.20 mg/m^3 with a mean of 0.65 mg/m^3. The results for individual samples appear in Table VI.

Pyrolosis of polyurethane materials may produce cyanide. A specimen of fabric containing the greatest fraction of polyurethane, S28-167, was heated for 4 hours in the tube furnace to determine whether cyanide is released at nominal molding temperature (205^{o}C). An apparent total of 16 μ g of cyanide, as HCN, was generated, representing an average gas concentration of 0.06 ppm. Because the cyanide concentration in the test solution approached the limit of detection for the analytical method, and because such small positive readings might result from interference of compounds other than HCN in the tube furnace effluent, the presence of this small amount of cyanide cannot be considered as unequivocally established.

The possibility of toluene-2,4-diisocyanate being released from polyurethane fabrics during molding was also considered. Fabric specimens were heated in the tube furnace to nominal molding temperature (205^{o}C). No TDI was detected in the effluent from fabric S28-167 (polyester - lycra blend). A specimen of fabric C28-388, a black, 100% polyester fabric with no apparent source of TDI, however, resulted in a positive change by the TDI tape detector.

Figure 1. Chromatogram generated by GC-MS analysis of tube furnace condensate from sample fabric S28-167.

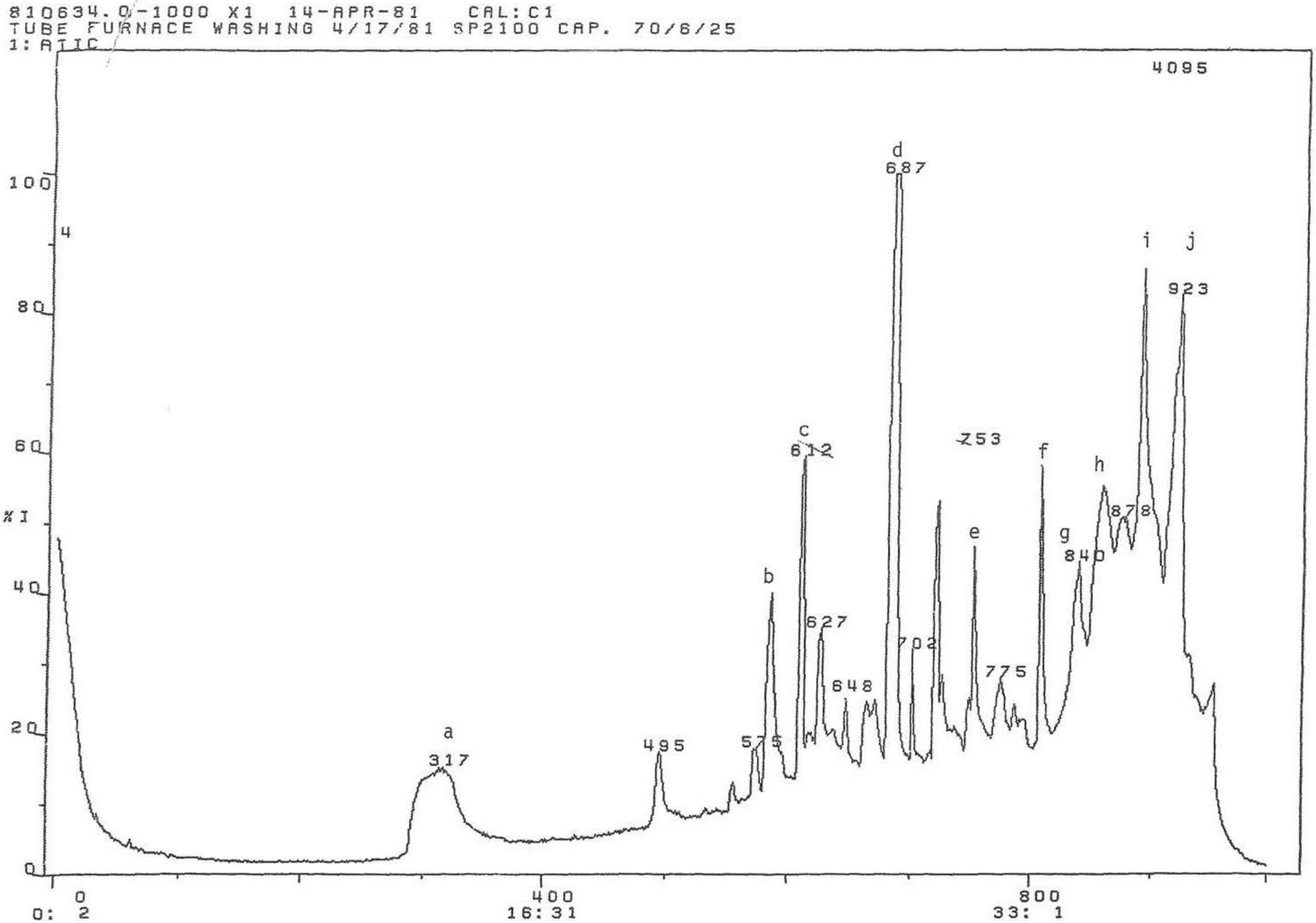

Table V

Distillate Component Identification - Mass Spectrometry Chromatogram

Peak	Description
a	Molecular ion, 86; consistent with fragmentation pattern, ethylene urea, imidazoledin-2-one, piperazine.
b	Molecular ion, 198; fragmentation pattern identical to that of bis(p-aminophenyl) methane.
c	Molecular ion, 312; empirical formula by exact mass $C_{20}H_{40}O_2$, fragmentation pattern consistent with butyl ester of hexadecanoic acid.
d	Molecular ion, 340; formula by exact mass $C_{22}H_{44}O_2$, fragmentation pattern consistent with n-butylester of stearic acid.
e	No molecular ion detected, fragments at m/e 355, 281, 207 characteristic of silicones.
f	same as e.
g	No molecular ion detected, fragmentation pattern and elemental composition of highest mass fragment indicate a fatty acid ester.
h	same as g.
i	No molecular ion detected, silicone compound with the same characteristic fragments as e and f
j	fragmentation pattern consistent with fatty acid ester.

Table VI

Air Sampling Results for Particulates and Organic Vapors, Various Molds and Fabrics During Normal Operations

Air Sample Number	Type Sample (Mins)	Location and Comments	Results*
CT-1002	Personnel, Charcoal Tube (184)	Fanny shaper and mold, Fabric (white) F28-167, Polyester, 21% ± 3% lycra 10 min. on break during sampling	< 0.01 ppm
OF-3106	Area, Filter (187)	Work area near mold listed above	1.20 mg/m^3
CT-1003	Personnel, Charcoal Tube (129)	Cup mold, fabric (black) C28-388, polyester 4 ply	< 0.01 ppm
OF-3086	Area, Filter (111)	Work area near mold listed above	0.54 mg/m^3
CT-1005	Personnel, Charcoal Tube (47)	Cup mold, fabric F28-388 (white) polyester 4 ply 12 min. on break during sampling	< 0.01 ppm insufficient sample for observable chromatograms
OF-3108	Personnel, Filter (137)	Same as above, different machine	0.17 mg/m^3
CT-1000 OF-3088 (in Tandem)	Personnel, Charcoal Tube and Filter (125)	Cup mold, fabric F28-388 (white) polyester	0.05 ppm 0.10 mg/m^3
CT-1001	Personnel, Charcoal Tube (38)	Separate cup mold fabric 8-28-127, (white) in-house lamination	0.03 ppm insufficient sample for observable chromatograms

* Charcoal tube data for total vapors was based on a molecular weight of 350.

Direct inquiry to the supplier of the TDI detector table could not identify any compounds with potential for positive interference. An aerosol containing pigment, which discolored the downstream portions of the tube furnace apparatus, may have been partially responsible for the observed discoloration of the detector tape.

At the time of the plant survey, air in the molding area was tested by means of detector tubes and found to be free of detectable amounts of formaldehyde. The limit of detection by this method is 1 ppm formaldehyde. A sample of insulation board, used to replace broken or loose insulation on the mold machines, was obtained from Playtex plant and was analyzed for asbestos type and quantity. The laboratory reported that the make-up of the insulation was primarily plaster with cellulose fiber; no asbestos was found. However, by inquiry to the Johns-Manville Company which manufactures the insulation board, it was learned that asbestos was a part of this type insulation until December 1978. Therefore, old insulation board being removed from the molds and insulation purchased prior to 1979 may contain asbestos. According to Johns-Manville Company, insulation with density of 46 lbs. per cubic foot (the density material being used by Playtex) was marked M (Maranite Board) - XL prior to December 1978 and did contain asbestos. After that date, insulation with density of 46 lbs. per cubic foot was marked M - XLO, and later M -I,and did not contain asbestos. Personnel at Playtex reported no marking on the boxes to identify the type insulation boards they had in storage. Orders for the insulation board do not come direct from Johns-Manville Company, but through a distributor. It is therefore possible that the material is cut to size and repackaged, so the absence of the M - XL mark is no assurance that old material is asbestos-free. Therefore, pre-1979 material should be handled as if it contains asbestos.

Building Ventilation:

The building housing the production and warehouse space is 150 feet wide and 425 feet long with an average ceiling height of about 15 feet (14 feet at eaves and 16 feet at ridge). This space is ventilated through four overhead supply air duct systems by four Carrier 60 ton air conditioning, 70 KW heating, units with 20 HP fan drive motors. Each of these units serves one quadrant of the building, with outlet grilles discharging horizontally at an elevation of about 10 feet. Each unit is equipped with an outside make-up air damper on the intake side of the fan and an outside smoke pump-out damper on the discharge side of the fan. All make-up air dampers and all but one of the pump-out dampers were closed at the time of the visit. (The pump-out damper on the southwest unit was partially open). Thus, return air inlet grille flow rates should generally represent the air flow rates through the distribution system.

The four return air inlet grilles, located in end walls of the building, are each about 4 feet high and 10 feet wide with lower edges about 1 foot above floor level. Estimates of inlet air velocity were made with an Alnor thermoanemometer. The results are:

Ventilation Unit	Approximate Average Inlet Air Velocity	Approx. System Airflow Rate
Northeast	350 ft/min	14000 ft^3/min
Southeast	200 ft/min	8000 ft^3/min
Northwest	200 ft/min	8000 ft^3/min
Southwest	200 ft/min	8000 ft^3/min

Because one of the four identical units was circulating substantially more air than the other three, it is clear that at least the three low units are operating at less than capacity.

Outside air was being drawn into the building through doors and other openings at the time of the visit. Such make-up air was required because exhaust ventilation hoods were in operation in an adhesive laminating room, and two wall mounted 30 inch diameter propeller fans were exhausting air (about 12 feet above floor level) from the molding area. Measurements of exhaust rates were not attempted, but exhaust rates of 5000 to 6000 ft^3/min each for hoods of the type and sizes of those in the adhesive room would be typical. Estimates for exhaust rates for the molding area wall fans are uncertain because fan rotation rate and building static pressure are not known. The rotation rate was estimated to be about 300 rpm; with building static pressure less than 0.1 inch of water, each fan should exhaust 3000 to 4000 ft^3/min. Thus, a reasonable estimate is that air is being exhausted from the building at a rate of about 15,000 to 20,000 ft^3/minute.

As the systems were operated at the time of observation, fugitive make-up air must enter the building through doors and other openings in amount equal to exhausted air. If this make-up air is 15,000 to 20,000 ft^3/min and if it mixes with building air, then this outside air will represent 25 to 35 percent of air being circulated by the Carrier unit air distribution systems. Controlled distribution of make-up air should be supplied in an amount at least as great as that exhausted from the building. If the exhaust air rate is in the order of 20,000 ft^3/min, then operation of the Carrier unit fans at a rate of about 15,000 ft^3/min each with dampers set so each takes 5,000 ft^3/min outside make-up air would distribute make-up air throughout the work area, and would balance exhaust air.

VII. DISCUSSIONS AND CONCLUSIONS

Specimens of fabrics used in the molding machines show weight loss, other than moisture, of about 0.1 to 0.5 percent (about 1 to 5 mg/g) upon being heated to molding temperature. The fraction of fabric weight lost in actual molding operations may be less or greater than this; the quantity of material that is capable of being volatilized from the fabric at molding temperature, however, is demonstrated by these results.

Gas chromatography-mass spectrometry analyses of material volatilized by heating one fabric to molding temperature in a nitrogen stream identified several compounds. Among them is bis (p-aminophenyl) methane (4,4'diaminodiphenylmethane). This compound is known to be a mucous membrane irritant. Silicone compounds which have moderate irritant effects, were also indicated.

Air samples, both personal samples and samples obtained near molding machines, showed < 0.01 to 0.05 ppm of volatile material (molecular weight of 350 assumed) which could be desorbed from charcoal sampling adsorbent. Gas chromatographic peaks from this material overlapped some of the peaks obtained by laboratory heating of fabric specimens. Membrane filter samples yielded concentrations ranging from about 0.1 to 1.2 mg/m^3 of particulate material.

A very small amount of cyanide was detected in materials volatilized from a fabric containing a polyurethane component when it was heated to molding temperature. Based upon thermo-gravimetric analysis of the fabrics, exposure to this agent is expected to be well below the OSHA standards and Threshold Limit Values for these two agents. TDI was not found in the tube furnace effluent from heating polyurethane fabrics.

Seventeen molders and five punch press operators were evaluated with medical questionnaires. The majority of the molders reported respiratory symptoms, primarily cough, and all reported symptoms of mucous membrane irritation at work. Five molders reported chest tightness, five reported symptoms of chronic post-nasal drainage, and two reported loss of sense of smell since beginning work in molding operation. None of the punch press operators reported acute respiratory symptoms, although two reported shortness of breath on exertion.

The universal reporting of respiratory symptoms by molding machine operators is consistent with the demonstrated generation of volatile materials (and subsequent condensation of fume), including a mucous membrane irritant, when molding fabrics are heated to molding temperatures, and with absence of control measures to prevent these materials from reaching the breathing zones of workers. In contrast, respiratory symptoms are not reported by punch press operators whose jobs do not involve generation of volatile materials.

It is concluded that respiratory symptoms reported by molding machine operators are associated with exposures to materials released in the course of heat molding operation and which enter the breathing zones of the machine operators.

VIII. RECOMMENDATIONS:

On the basis of observations to date and good industrial hygiene practice the following recommendations are made:

1. The 4-unit building air distribution system should be examined and adjusted for proper operation, including provision for outside make-up air in amount at least equal to the amount of air removed from the building by exhaust ventilation units.

2. Engineering controls should be devised to prevent molding process emissions from entering breathing zones of molding machine operators.

3. Until effective engineering controls are devised, molding machines should be oriented to take advantage of any persistent room air currents which cause process emission to drift away from, rather than toward, workers.

4. Molding machine insulation boards, either those removed from machines or those taken from storage, which cannot be shown to have been manufactured from stock made since December, 1979, should be handled and disposed of as though they contain asbestos.

IX. REFERENCES

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2. Formaldehyde: Evidence of Carcinogenicity, NIOSH Current Intelligence Bulletin 34, DHHS (NIOSH) Publication No. 81-111, April 15, 1981.

3. Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1980, American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio, 1980.

4. U.S. Dept. of Labor, Occupational Safety and Health Administration (1976): General Industry Safety and Health Standards, OSHA 2206 (29 CFR 1910.100) 1976.

5. 1979 Registry of Toxic Effects of Chemical Substances, DHHS (NIOSH) Publication No. 80-111, September, 1980.

X. AUTHORSHIP AND ACKNOWLEDGEMENTS

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XI. DISTRIBUTION AND AVAILABILITY

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Copies of this report have been sent to:

(a) International Playtex, Inc., Newnan, GA

(b) U.S. Department of Labor, OSHA, Region IV

(c) NIOSH Region IV

(d) Georgia Department of Human Resources

APPENDIX A.

HEALTH STATUS QUESTIONNAIRE

Health Screening History

Respiratory History

Playtex Plant: Health Hazard Evaluation 2/18/80

A summary of the results of your medical examination will be sent to you. The detailed results of the examination will be made available to your physician. Please supply us with your and your physician's name and address so that the results can be sent.

Your name: ______________________________

Address: ______________________________

____

Your Physician's name: ______________________________

his address: ______________________________

____

Please fill out the attached medical questionaires as best as you can. We will review them with you.

HEALTH SCREENING HISTORY

Name: ______________________
SS#: ______________________
Date: __________ Date of Employment
Company: ______________________

Are You Allergic to:

	YES
Tetanus Toxoid?	( )
Antibiotic (s)?	( )
Other?	( )

Have you ever had:

	YES	In Last Year?	Could this be Work-Related?
Diabetes?	( )	( )	( )
Heart trouble?	( )	( )	( )
Kidney problems?	( )	( )	( )
Arthritis?	( )	( )	( )
Cancer or tumor?	( )	( )	( )
Epilepsy?	( )	( )	( )
Nervous Breakdown?	( )	( )	( )
Anemia?	( )	( )	( )
Stomach trouble (ulcer)?	( )	( )	( )
Hepatitis (jaundice)?	( )	( )	( )
Hernia (rupture)?	( )	( )	( )
High blood pressure?	( )	( )	( )
Asthma?	( )	( )	( )
Back Trouble?	( )	( )	( )
Fertility problems?	( )	( )	( )
Blurred or double vision?	( )	( )	( )
Poor hearing?	( )	( )	( )
Nose or eye irritation?	( )	( )	( )
Trouble smelling or poor taste sense?	( )	( )	( )
Teeth or gum problems?	( )	( )	( )
Trouble swallowing?	( )	( )	( )
Persistent hoarseness?	( )	( )	( )
Unusual shortness of breath?	( )	( )	( )
Persistent cough or wheezing?	( )	( )	( )
Pain or tightness in your chest?	( )	( )	( )
Weight loss or loss of appetite?	( )	( )	( )
Bloody or black bowel movements?	( )	( )	( )
Frequent diarrhea or constipation?	( )	( )	( )
Frequent nausea or stomach pain?	( )	( )	( )
Excessive fatigue or tiring easily?	( )	( )	( )
Painful or swollen joints?	( )	( )	( )
Weakness of arms or legs?	( )	( )	( )
Numbness or aching of hands or feet?	( )	( )	( )
Frequent or severe headaches?	( )	( )	( )
Dizziness or fainting?	( )	( )	( )
Nervousness affecting home life or work?	( )	( )	( )
Unusual bouts of anger or irritability?	( )	( )	( )
Suspisciousness of others?	( )	( )	( )
Poor memory or forgetfulness?	( )	( )	( )
Problem with depression?	( )	( )	( )
Tremor of your hands?	( )	( )	( )
Difficulty with balance or instability?	( )	( )	( )
Sore that does not heal?	( )	( )	( )
An unusual or chronic rash?	( )	( )	( )

How many cigarettes do you smoke a day?________ How many cups of coffee?__________
Do you drink alcoholic beverages regularly?________
What medicines are you taking?______________________________
Are you under a doctors care for any problems?_______

Name: ______________

Date: ______________

RESPIRATORY HISTORY

(N/A = not applicable)

	YES	NO	N/A
1. Do you usually cough first thing in the morning or on getting up?	___	___	
(Count a cough with first smoke or on first going out of doors. Exclude throat clearing or a single cough.)			
2. Do you cough like this on most days for as much as three months each year?	___	___	___
3. Do you cough at work?	___	___	
4. Do you usually bring up some phlegm from your chest first thing in the morning or on getting up?	___	___	
(Count phelgm with the first smoke or on first going out of doors. Exclude phelgm from the nose. Count swallowed phlegm.)			
5. Do you bring up phlegm like this on most days for as much as three months each year?	___	___	___

6. In the past three years, have you had a period of (increased) cough and phlegm lasting 3 weeks or more? ___ ___

7. Have you had more than one such period? ___ ___

8. Does your chest ever feel tight or your breathing become difficult? ___ ___

9. Do you get this apart from colds? ___ ___

(If YES: specify ... (Interviewer to code)
(a) With Exercise ___ ___
(b) At Work ___ ___
(c) Any Other Time ___ ___
If disabled from walking by skeletal or other physical disability put 'X' here. ___

10. Are you troubled by shortness of breath, when hurrying on the levels or walking up a slight hill? ___ ___
(If 'NO' omit questions 11 and 12)

11. Do you get short of breath walking with other people of your own age on level ground? ___ ___
(If 'NO' omit question 12)

12. Do you have to stop for breath when walking at your own pace on level ground? ___ ___

13. Do you usually have a stuffy nose or catarrh at the back of your nose in the winter? ___ ___

14. Do you have this in the summer? ___ ___
(If 'NO' to both questions 13 and 14, go to question 16)

15. Do you have this on most days for as much as three months each year? ___ ___

16. During the past 3 years have you had any chest illness which has kept you off work or from your usual activities for as much as a week? ___ ___

17. Did you bring up more phlegm than usual in any of these illnesses? ___ ___

18. Have you had more than one illness with phlegm like this in the last 3 years? ___ ___

HAVE YOU EVER HAD:
(Give relevant details after each positive answer.)

19. An injury or operation affecting your chest? ___ ___

20. Heart trouble? ___ ___

21. Bronchitis? ___ ___

22. Pneumonia? ___ ___

23. Pleurisy? ___ ___

24. Pulmonary Tuberculosis? ___ ___

25. Bronchial Asthma? ___ ___

26. Eczema? ___ ___

27. Dermatitis? ___ ___

28. Pneumoconiosis? ___ ___

29. Byssinosis? ____________ ___ ___

____

30. Other chest troubles? ____________ ___ ___

____

31. Have you ever smoked? ____________ ___ ___
(Record 'NO' if subject has never smoked as much as one cigarette a day, or 1 oz. tobacco a month, for as long as one year)

32. Age when stopped ___ years. Was this in the last month? ___ ___
If 'YES' to 31 and 32, fill in figures below:

	AMOUNT SMOKED NOW	AMOUNT SMOKED BEFORE STOPPING
Cigarettes/day (Average including weekends)	___	___
Oz. tobacco/week (handrolled)	___	___
Cigars/week (large)	___	___
Cigars/week (small)	___	___

Occupation (1st Interview Only)

(Record on lines the years in which subject has worked in any of these industries, e.g., 1960-1963)

	YES	NO
33. Have you ever worked in a dusty job? ____________	___	___
34. In a coal mine ____________	___	___
35. In any other mine? ____________	___	___
36. In a quarry? ____________	___	___
37. In a foundry? ____________	___	___
38. In a pottery? ____________	___	___
39. In a cotton, flax or hemp mill? ____________	___	___
40. With asbestos? ____________	___	___
41. In any other dusty job? ____________ If 'YES', specify ____________	___	___
42. Have you ever been exposed regularly to irritating gas or chemical fumes? If 'YES', give details of nature and duration ____________	___	___

Occupation (Follow-Up only)

43. What is your present job? ____________

44. How long have you been doing it? ____________

45. What was your previous job in the factory? ____________

____

APPENDIX B.

Thermo-Gravimetric Analysis Charts

Molding Fabrics

F28-167

S28-167

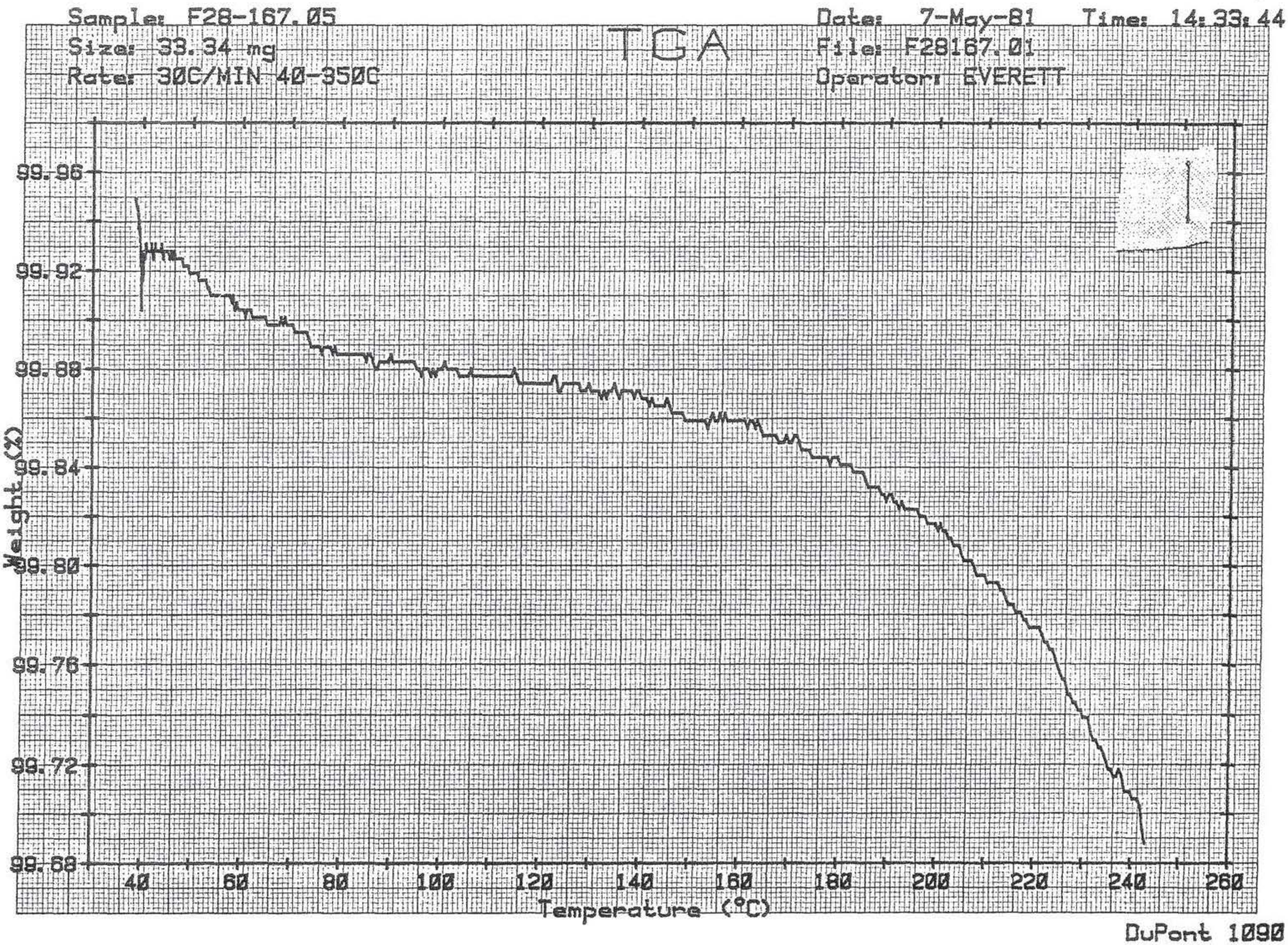
C28-388

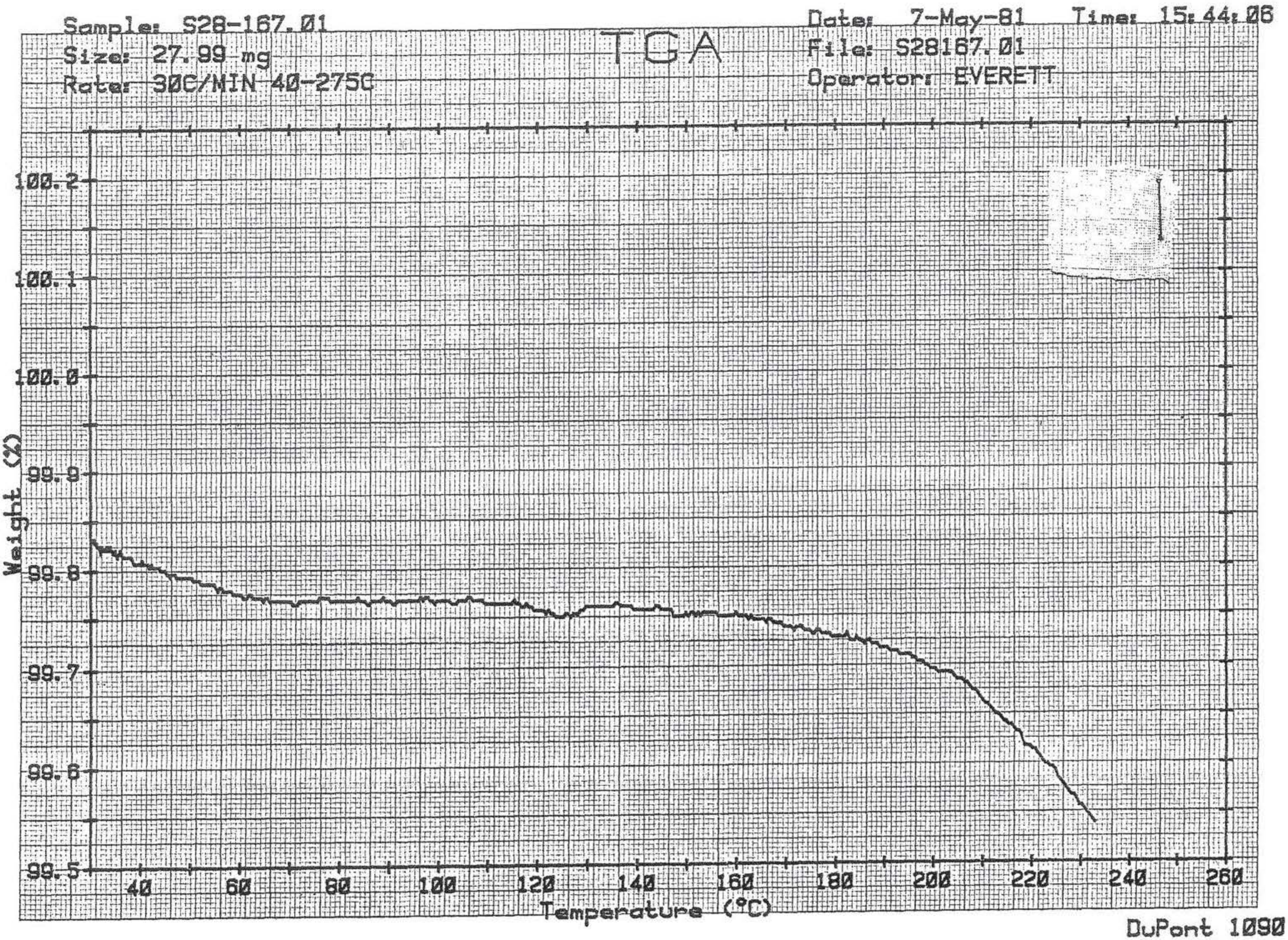
F28-388

X28-388

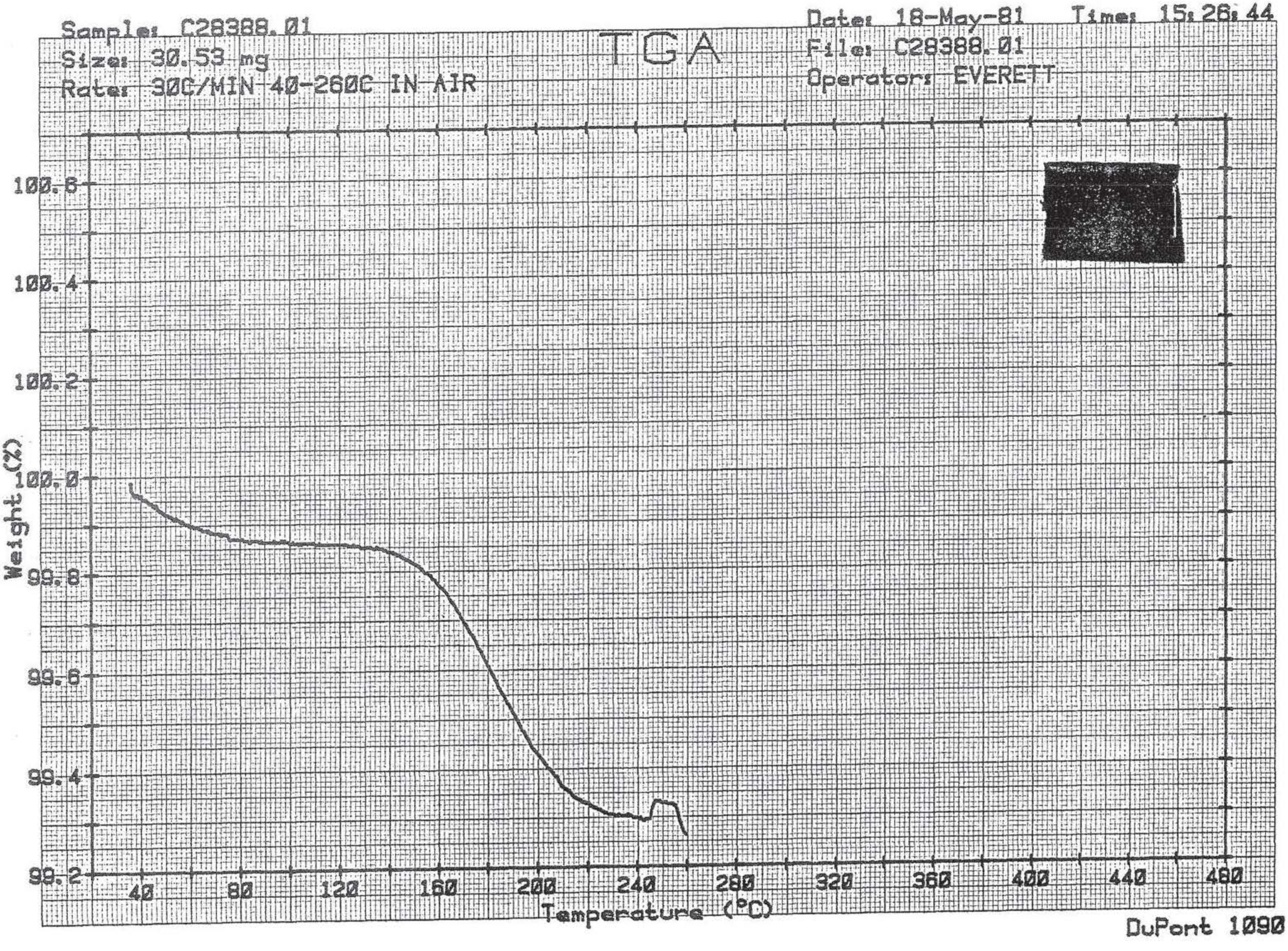
F28-608

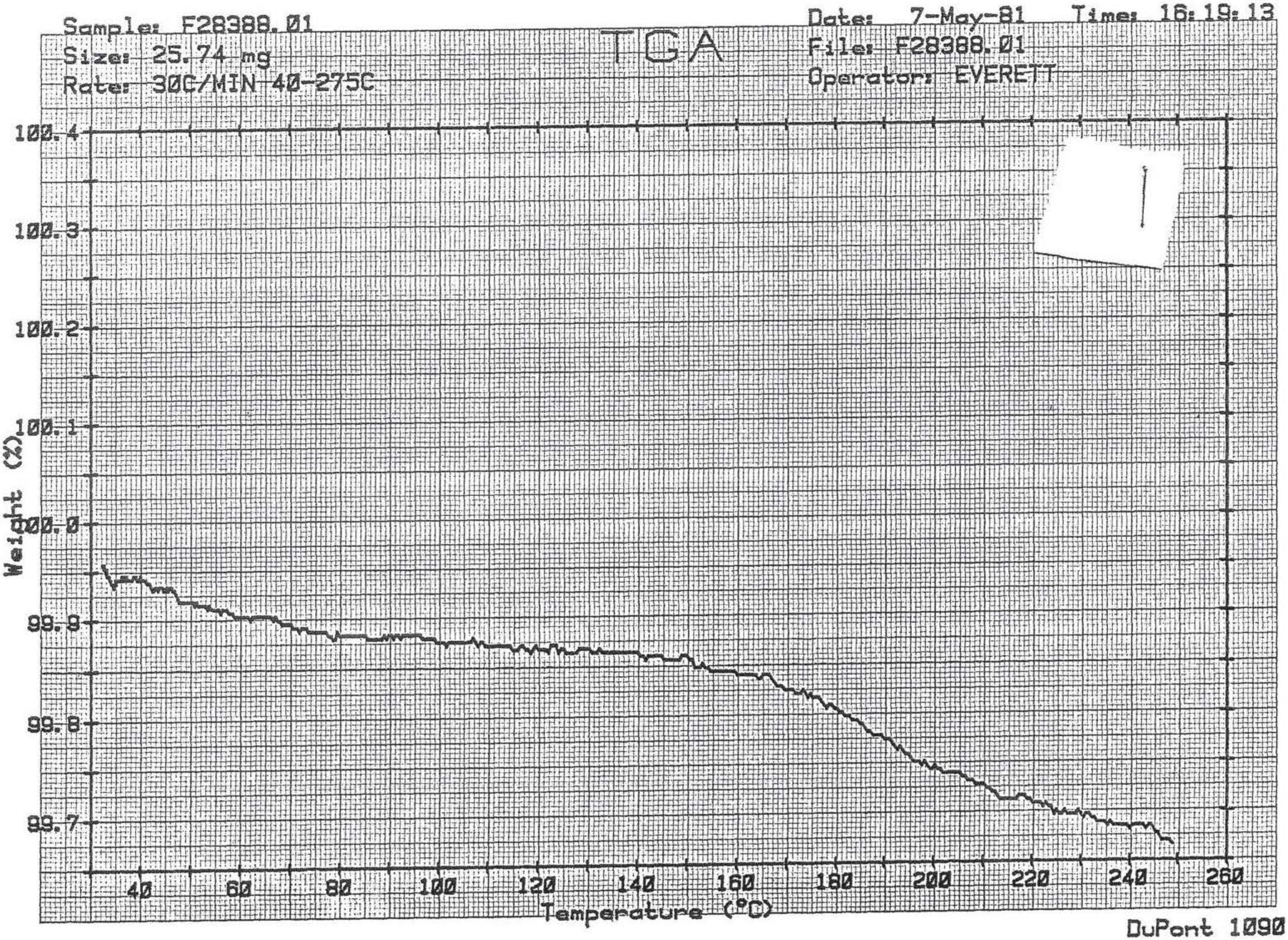
S28-608

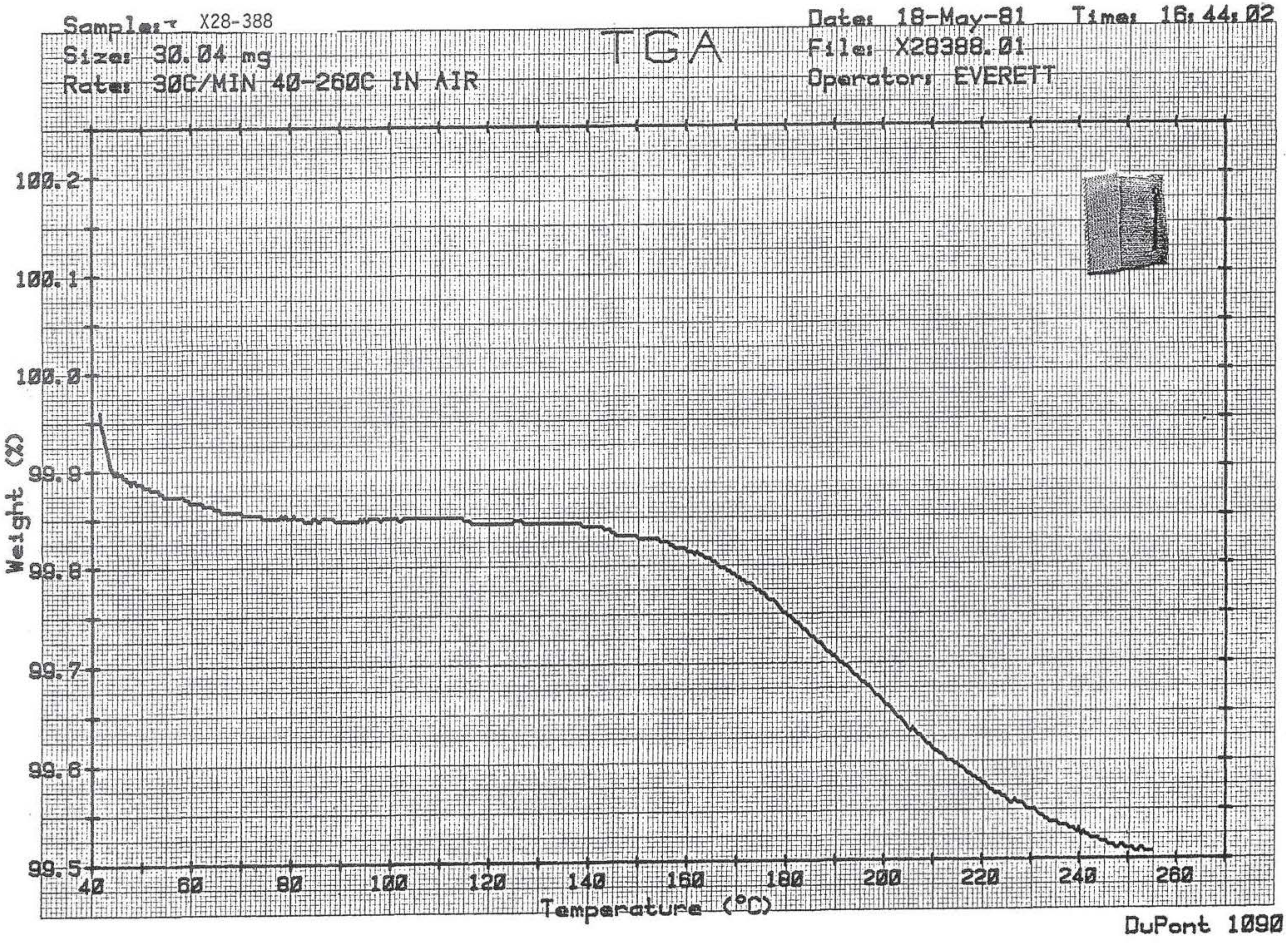

Sample: F28-167.05
Size: 33.34 mg
Rate: 30C/MIN 40-350C
TGA
Date: 7-May-81
Time: 14:33:44
File: F28167.01
Operator: EVERETT
99.96
99.92
99.88
99.84
99.80
99.76
99.72
99.68
Weight (%)
40
60
80
100
120
140
160
180
200
220
240
260
Temperature (°C)
DuPont 1090

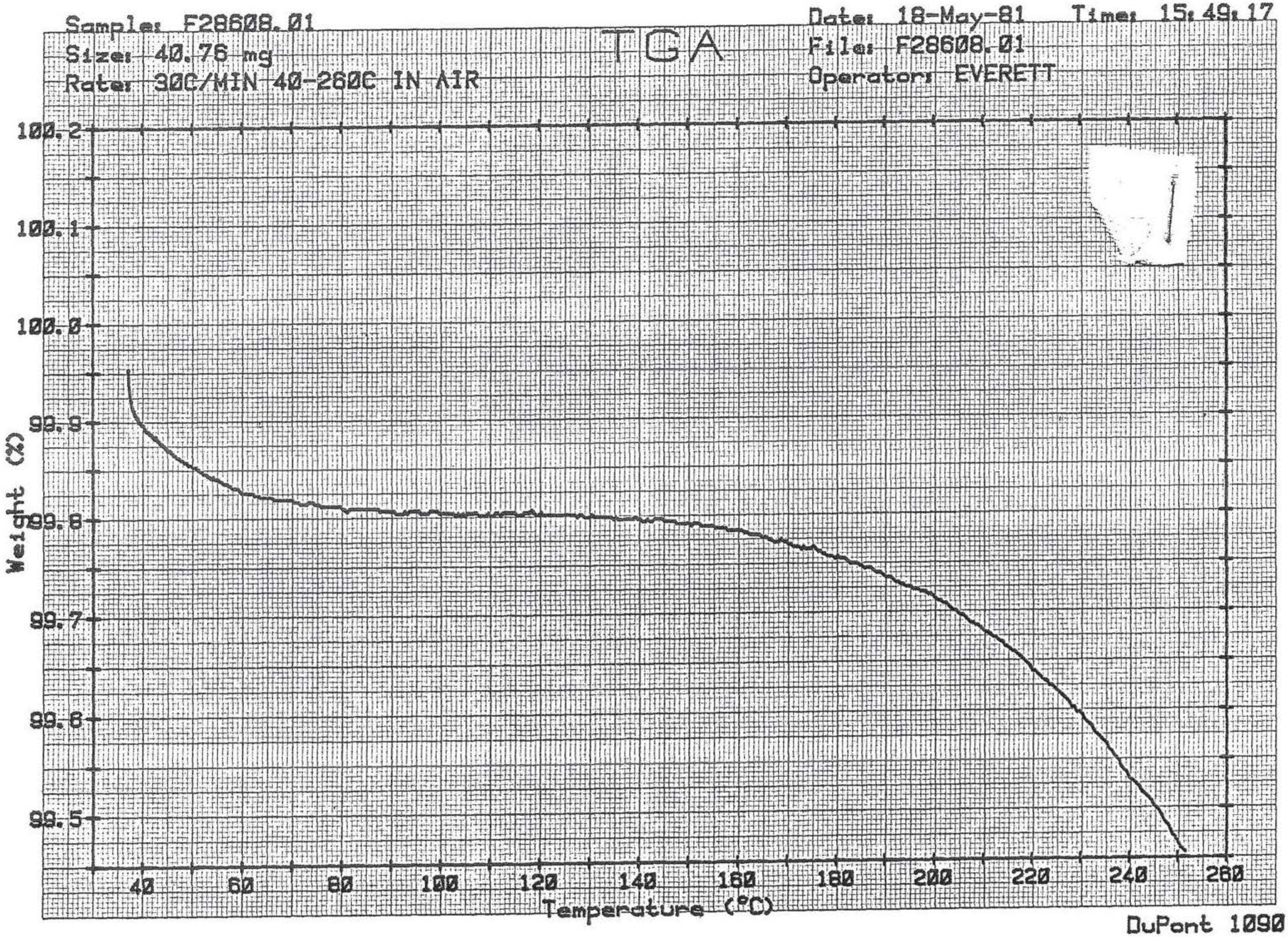


Sample: S28-167.01
Size: 27.99 mg
Rate: 30C/MIN 40-275C
TGA
Date: 7-May-81
Time: 15:44:06
File: S28167.01
Operator: EVERETT
Weight (%)
100.2
100.1
100.0
99.9
99.8
99.7
99.6
99.5
40
60
80
100
120
140
160
180
200
220
240
260
Temperature (°C)
DuPont 1090


Sample: C28388.01
Size: 30.53 mg
Rate: 30C/MIN 40-260C IN AIR
TGA
Date: 18-May-81
Time: 15:26:44
File: C28388.01
Operator: EVERETT
[redacted]
100.6
100.4
100.2
100.0
99.8
99.6
99.4
99.2
Weight (%)
40
80
120
160
200
240
280
320
360
400
440
480
Temperature (°C)
DuPont 1090


Sample: F28388.01
Size: 25.74 mg
Rate: 30C/MIN 40-275C
TGA
Date: 7-May-81 Time: 16:19:13
File: F28388.01
Operator: EVERETT
100.4
100.3
100.2
100.1
100.0
99.9
99.8
99.7
Weight (%)
40
60
80
100
120
140
160
180
200
220
240
260
Temperature (°C)
DuPont 1090


Sample: X28-388
Size: 30.04 mg
Rate: 30C/MIN 40-260C IN AIR
TGA
Date: 18-May-81
Time: 16:44:02
File: X28388.01
Operator: EVERETT
Weight (%)
100.2
100.1
100.0
99.9
99.8
99.7
99.6
99.5
40
60
80
100
120
140
160
180
200
220
240
260
Temperature (°C)
DuPont 1090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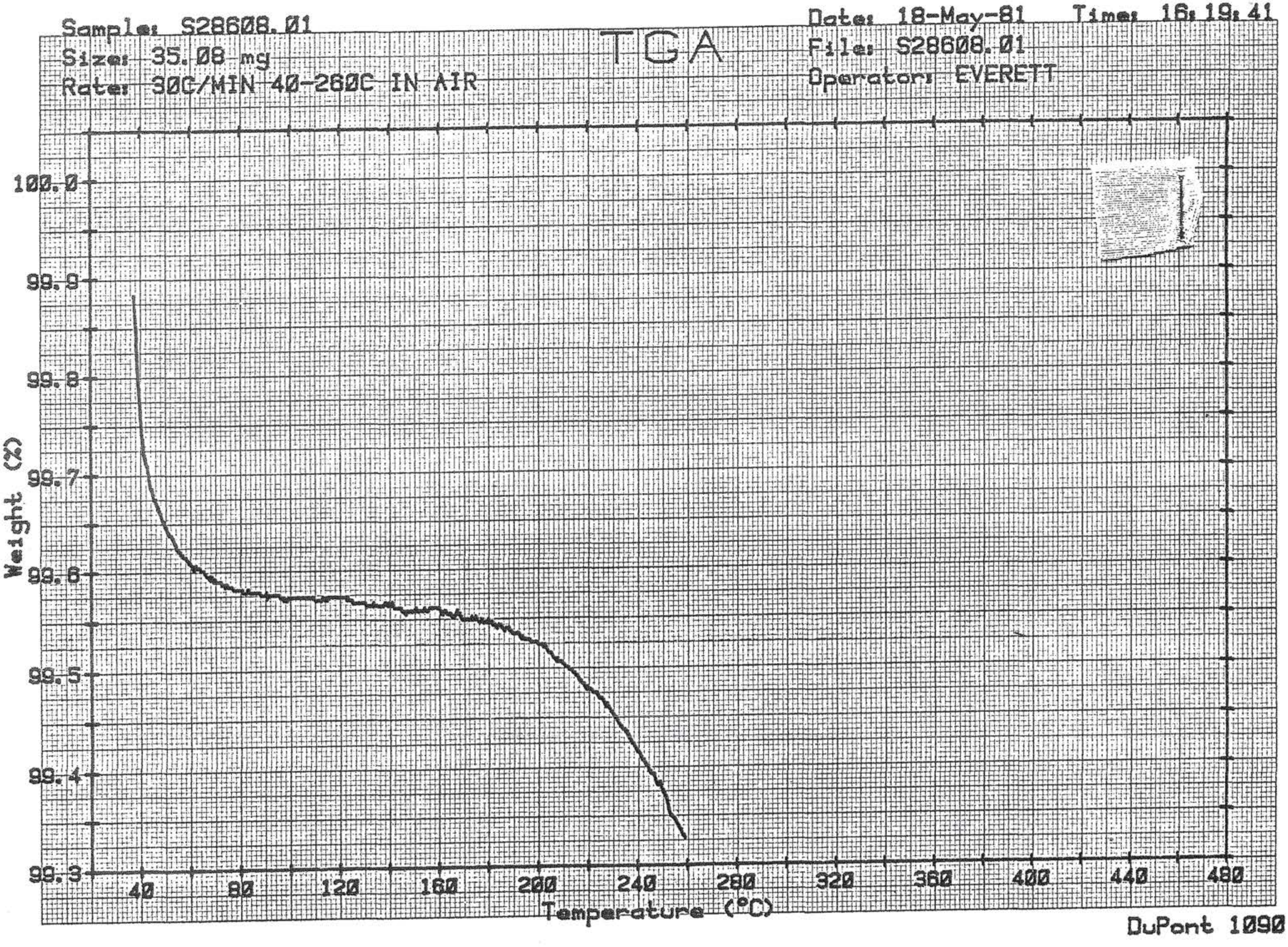
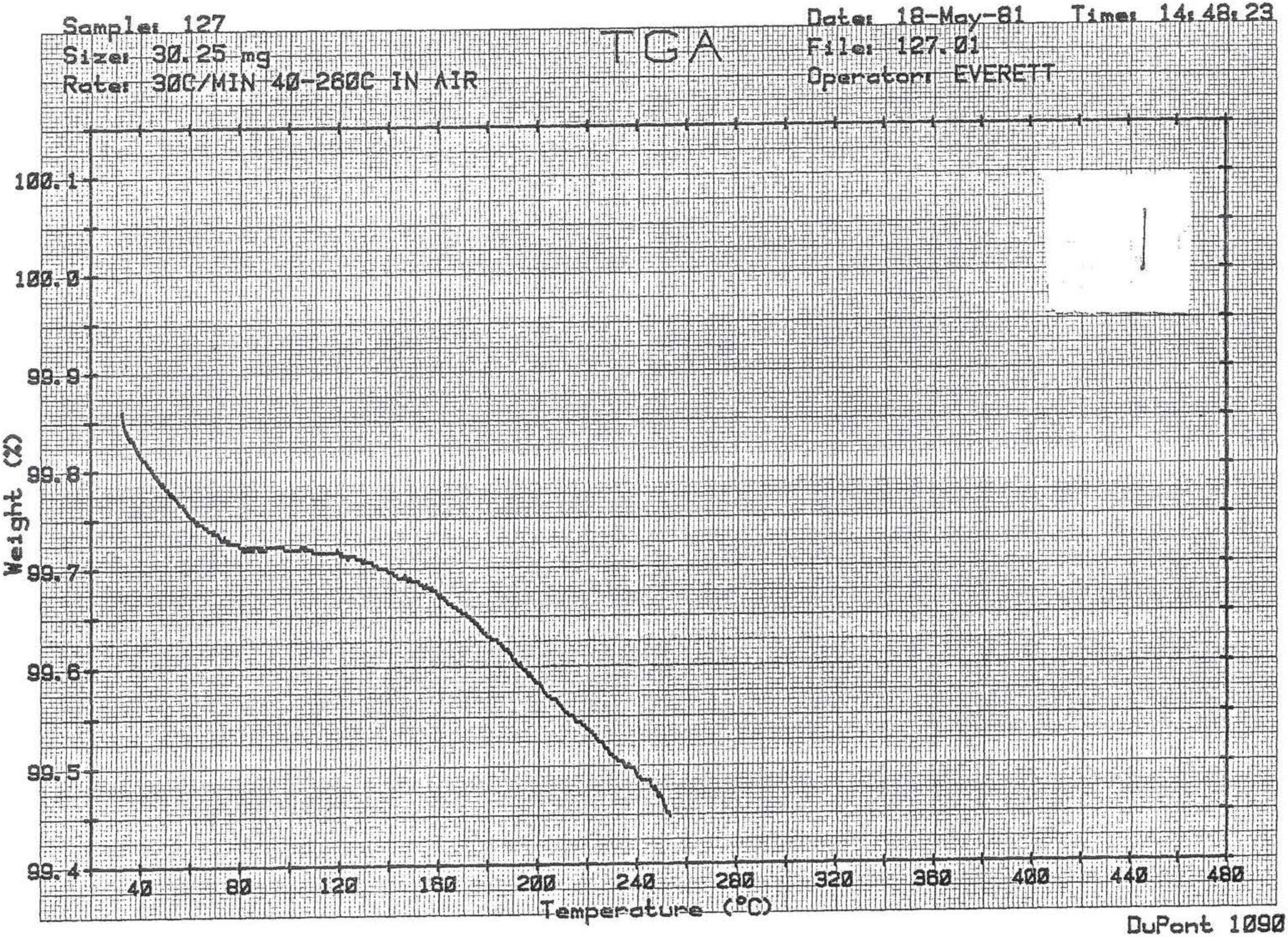
Size: 40.76 mg
Rate: 30C/MIN 40-260C IN AIR
TGA
Date: 18-May-81 Time: 15:49:17
File: F28608.01
Operator: EVERETT
Weight (%)
100.2
100.1
100.0
99.9
99.8
99.7
99.6
99.5
40
60
80
100
120
140
160
180
200
220
240
260
Temperature (°C)
DuPont 1090


Sample: S28608.01
Size: 35.08 mg
Rate: 30C/MIN 40-260C IN AIR
TGA
Date: 18-May-81
Time: 16:19:41
File: S28608.01
Operator: EVERETT
Weight (%)
100.0
99.9
99.8
99.7
99.6
99.5
99.4
99.3
40
80
120
160
200
240
280
320
360
400
440
480
Temperature (°C)
DuPont 1090


Sample: 127
Size: 30.25 mg
Rate: 30C/MIN 40-280C IN AIR
TGA
Date: 18-May-81
Time: 14:48:23
File: 127.01
Operator: EVERETT
100.1
100.0
99.9
99.8
99.7
99.6
99.5
99.4
Weight (%)
40
80
120
160
200
240
280
320
360
400
440
480
Temperature (°C)
DuPont 1090

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