ANTWERP BLOOD TESTING RESULTS FROM JUNE, 1995

1. Purpose of the Blood Testing Program (BTP)

Blood testing for the presence of FC 95 (PFOS) and FC 143 (PFOA) was completed at the Antwerp plant in June, 1995. This was undertaken to quantitate individual exposures as well as to gain additional insights into the mechanism of exposure. Specifically, the following insights were obtained through this program:

A. Individual measures of PFOS and PFOA, chemistry profiles, blood counts, and occupational histories were obtained on all participants. *(Feedback to individuals has already been done via independent communication. A sample of this letter is included in the information preceding the tables.)*

B. Areas within the Antwerp facility were compared to one another in terms of individual exposures.

C. Comparisons of exposure levels were made to other fluorochemical manufacturing facilities.

D. An examination was made of the relationship of fluorochemical blood levels to other laboratory parameters.

2. What was done

This program consisted of a medical and work history questionnaire (see attached), blood chemistries (lipid levels, liver function tests, kidney function tests, blood sugar, calcium), blood counts (hemoglobin, hematocrit, white blood cell count, platelet count, differential counts), and blood levels of PFOA and PFOS.
In addition, for those workers who were felt to have the potential for more exposure blood hormone levels (estradiol, testosterone, LH, FSH, sex hormone binding globulin, cortisol, 17-hydroxy progesterone, TSH) were also done.

Multiple laboratories were used in the analyses. The United Hospital Lab in St. Paul, performed blood chemistry and blood count tests on all participants. Hormones were measured at the University of Minnesota Dept. of Laboratory Medicine and Pathology. Standardized hormone assay kits were used. These kits were the same kits that have been used previously in conjunction with other testing programs in Decatur and Cottage Grove. PFOA and PFOS tests were conducted via 3M's Environmental Technology Services in St.

Paul. The method used in this determination consisted of a standardized extraction technique developed by Ylinen et. al.(Arch. Environ. Contam. Toxicol. 14:713-717, 1985). This technique uses tetrabutylammonium to ion-pair with PFO and PFOS in serum, and the ion-pairs are extracted with ethyl acetate. The abstraction was then analyzed using high performance liquid chromatography-thermospray mass spectrometry. This technique has been found reliable in previous testing.

Obtaining the medical and work history portion of this effort was handled locally by Antwerp personnel, using the plant physician to translate the questionnaire from English to Flemish. Employees essentially filled in questionnaires with assistance from plant personnel.

3. Descriptive results

Means, minimum and maximum values are listed in Table 1 for 55 variables. This is a complete listing of variables for which information was gathered. 93 individuals participated in the program. Their average age was 36 years. The mean PFOS value was 1.83 ppm. The mean PFOA value was 1.13 ppm. The highest PFOS value was 9.9 ppm while the highest PFOA value was 13.2 ppm. Comparison distributions for Cottage Grove and Decatur plants is listed in Appendices 1 and 2.

Other mean values of interest included an average time worked for 3M of 11 years, an average blood pressure of 125/78, an average of cigarette smoking of 15 years, an average of 9 drinks per week, an average weight of 163 lbs. (74 Kg), an average height of 5 feet, 9.6 inches (176.7 cm), and an average total cholesterol of 212 mg%. Hemoglobin, white blood cell count, red blood cell count, platelet count, liver function tests, and kidney function tests all revealed only sporadic values out of the normal range.

Tables 2 and 3 indicate the relationship of PFOS and PFOA levels (respectively) to location of the employees' current jobs. As shown, the highest levels of PFOS were found in workers who currently are in the new part of building 3. Their average PFOS level was 4.03 ppm for 15 individuals. For PFOS, background levels are around 0.35 ppm based on administration and QC lab personnel levels.

Building 16 revealed the highest PFOA mean (2.8 ppm for 13 individuals). Background levels for PFOA are around 0.5 ppm in non-exposed jobs.

This same relationship exists when we examined the longest held job. In this case those people who had their longest job at building 3 had the highest PFOS levels (4.45 ppm for 15 people). Those who indicated that their longest held job was in Building 16 had the highest PFOA levels (2.88 ppm for 14 individuals).

In terms of personal hygiene and its effect on blood levels of fluorochemicals, in the Antwerp workers there does not appear to be any relationship. There was no significant difference in PFOA or PFOS levels in those who washed their hands frequently vs. those who washed infrequently. Likewise, for those who laundered their work clothes frequently there were no differences in PFOA or PFOS levels vs. those who washed their clothes infrequently. More frequent skin contact with chemicals in general did not seem to be related to higher PFOA or PFOS levels.

Individuals indicated that they had experienced the following types and numbers of diseases:

Hepatitis A or B, 5 individuals
Cancer, type unspecified, 1 individual
Abnormal liver tests, 4 individuals
Prostatic hypertrophy, 1 individual
Osteoporosis, 1 individual
Diabetes mellitus, 1 individual

Tables 4A and B are correlation matrices of variables associated with PFOA and PFOS for the entire group of workers. This is a preliminary step in the assessment of these chemicals to potential health problems. (The second step of this process is to do multivariate statistical analyses which will be forthcoming under separate cover.) However, in general, the simple correlations are a good representation of what will show up in the multivariate analyses. For the simple correlations, there are three values listed, the correlation coefficient (top), the p-value (middle) and the number of people in the analysis (bottom). For a significant statistical association in this setting, a p-value of less than .01 is considered significant. As the tables indicate, there were no strong associations with any of the blood test results. There are weak associations (see below) of PFOA and alkaline phosphatase (a liver enzyme) as well as PFOS and creatinine (an indicator of kidney function). In the latter, the relationship shows that with increasing PFOS levels, kidney function improves. The relationship is therefore of no clinical consequence.

Tables 5A and B are correlation matrices of variables associated with PFOA and PFOS for the group of workers who were felt to have more likely exposures. Again, there are few associations that are significant. Alkaline phosphatase is not correlated with PFOA in this group, which should have more exposure. Included in these tables are the hormone values, some of which have been found to have associations with PFOA in the animal literature. Again, there is no strong relationship indicated with any of the hormone variables. There were, however, weak relationships found between PFOA and triglycerides (corr. coef.=.48, p=.0005). The significance of which is in question, since this relationship has never appeared in the medical or toxicology literature and is likely to be a chance finding.

4. Impression

Overall, the mean PFOA and PFOS values for Antwerp are lower than Cottage Grove and Decatur. Also, the maximum values are considerably lower than the other plants. My feeling is that exposure in Antwerp is minimal and seems to be under control. Whether this is due to a difference in processing or to individual hygiene/safety practices or all of these is not known.

Whatever exposures do take place seem to be focused in building 3 (new part) in the case of PFOS and building 16 in the case of PFOA.

In terms of diseases present in current workers (which represents an incomplete ascertainment) there do not appear to be obvious problems in excess. Neither are there diseases present which would be of concern, relative to the animal literature.

In regard to the blood chemistries and blood counts, these appear to be unrelated to PFOS or PFOA levels. However, there are 9 individuals who have indicated some type of liver problem currently or in the past. This appears to be related to viral etiologies for the most part. There were no relationships of liver function abnormalities and PFOA or PFOS in the simple correlations. This needs to be further assessed in the multivariable analyses.

Likewise, there do not appear to be relationships of PFOA and PFOS to any of the hormones measured.

In terms of the general health parameters of the plant, there appears to be considerable smoking as well as alcohol use. 33% of the participants indicated that they currently

smoke. (This is greater than the smoking rates in Minnesota, which run around 25%.) 32% of the participants indicated that they have more than 10 alcohol-containing drinks per week (range was 10-42 drinks per week). Smoking and drinking rates are clearly higher than in other chemical plants in the U.S. and probably reflect European customs to some degree.

5. **Recommendations**

Based on the above information the following suggestions are being made. First of all, it makes sense to look further into the processes for buildings 3 and 16, since these had the highest levels of PFOA and PFOS. It would make less sense to look at individual hygiene, since the results were fairly uniformly distributed over the 15 workers in this area. But, this is an option. Of concern would be the possibility of not only respirable exposure but also skin exposure.

It would be helpful for the plant to share this information with the work crews and to open up the dialogue between individual workers and the plant physician in this topic matter. Additionally, it has been our practice in the US. to have periodic updates in regard to any important toxicology studies that appear in the literature (human or animal), in an ongoing way. It's important to relay the information that although presumed to be without human health problems, workers need to follow strict safety precautions when working with them, as they would with any potential chemical exposure.

A repeat of this assessment should be undertaken periodically. In the US. plants, this assessment is performed every two years. It becomes more of an expected work practice and facilitates future communication with workers.

In the US., we are establishing a disease surveillance system for workers in the fluorochemical plants. This is designed to identify diseases in fluorochemical workers that have been described in animal studies. It is used as a mechanism to further enhance our ability to expediently find about these issues, if they do occur. Alternatively, this would also assist us in defending the company against false claims. Although the Belgium regulations may prohibit this, something similar to this would be helpful there. This should be explored in further detail.

The multivariate statistical analyses need to be finalized here before this project is complete. That should be taking place over the next few weeks. The additional analyses are not expected to alter the above comments. This effort will focus on the liver function tests, primarily.

One final note. It should be mentioned that the blood gathering and shipping processes from Antwerp to Minnesota occurred without a single error. All tubes were collected and analyzed here without a loss. Additionally, it appears that the plant participation for this effort was the highest of any of the fluorochemical exam programs in the recent past. The people who helped with this effort in Antwerp need to be congratulated on a job well done.

Please feel free to call either of us with any questions or comments that you may have.

Jeffrey H. Mandel, M.D., M.P.H.
Associate Medical Director

Jean Burris, R.N., O.H.N., M.P.H.
Project Co-ordinator

11/6/95

October 10, 1995

TO:

FROM: Jeff Mandel, M. D., 3M Medical Department

Your blood test for fluorine this year has been completed. Two types of fluorine were measured. The first one reflects FC 143. Your measured level was 2.000 ppm (parts per million). The average for people at your plant was 1.5 ppm. The second results was for FC 95. Your measured level was 4.200 ppm. The average for people at your plant was 1.9 ppm.

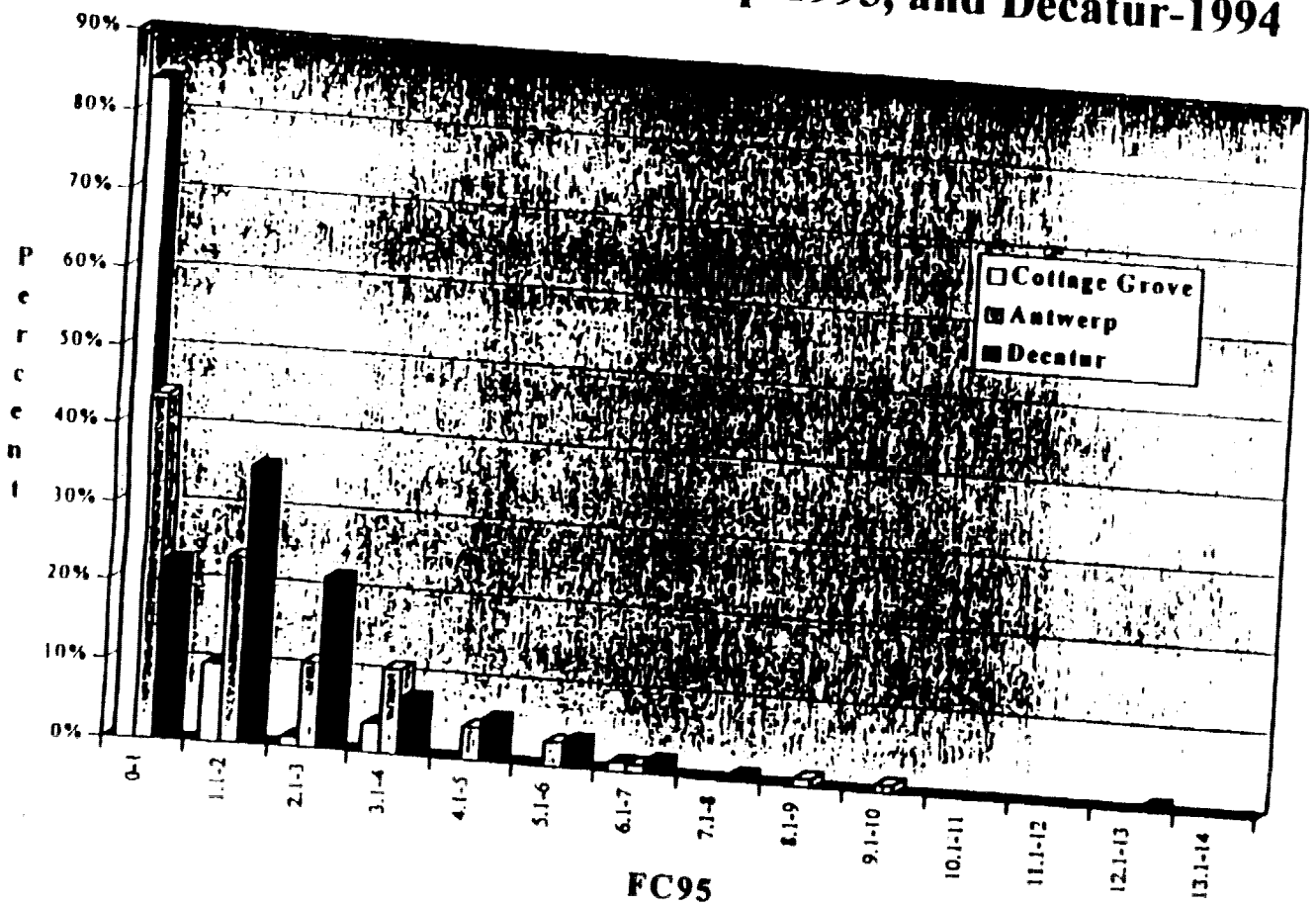
If your level was greater than 5 ppm, you should check with your supervisor regarding safe handling of these chemicals.

We will continue to give you feedback about the significance of the blood levels, from a health perspective. In the meantime, we're recommending that all employees with potential exposure to these compounds use strict safety precautions whenever possible. Check with your supervisors if you have any questions about safe handling and proper protection issues.

Appendix 1

Fluorine Test Results

Distribution of FC95 Values at Three Locations: Cottage Grove-1995, Antwerp-1995, and Decatur-1994

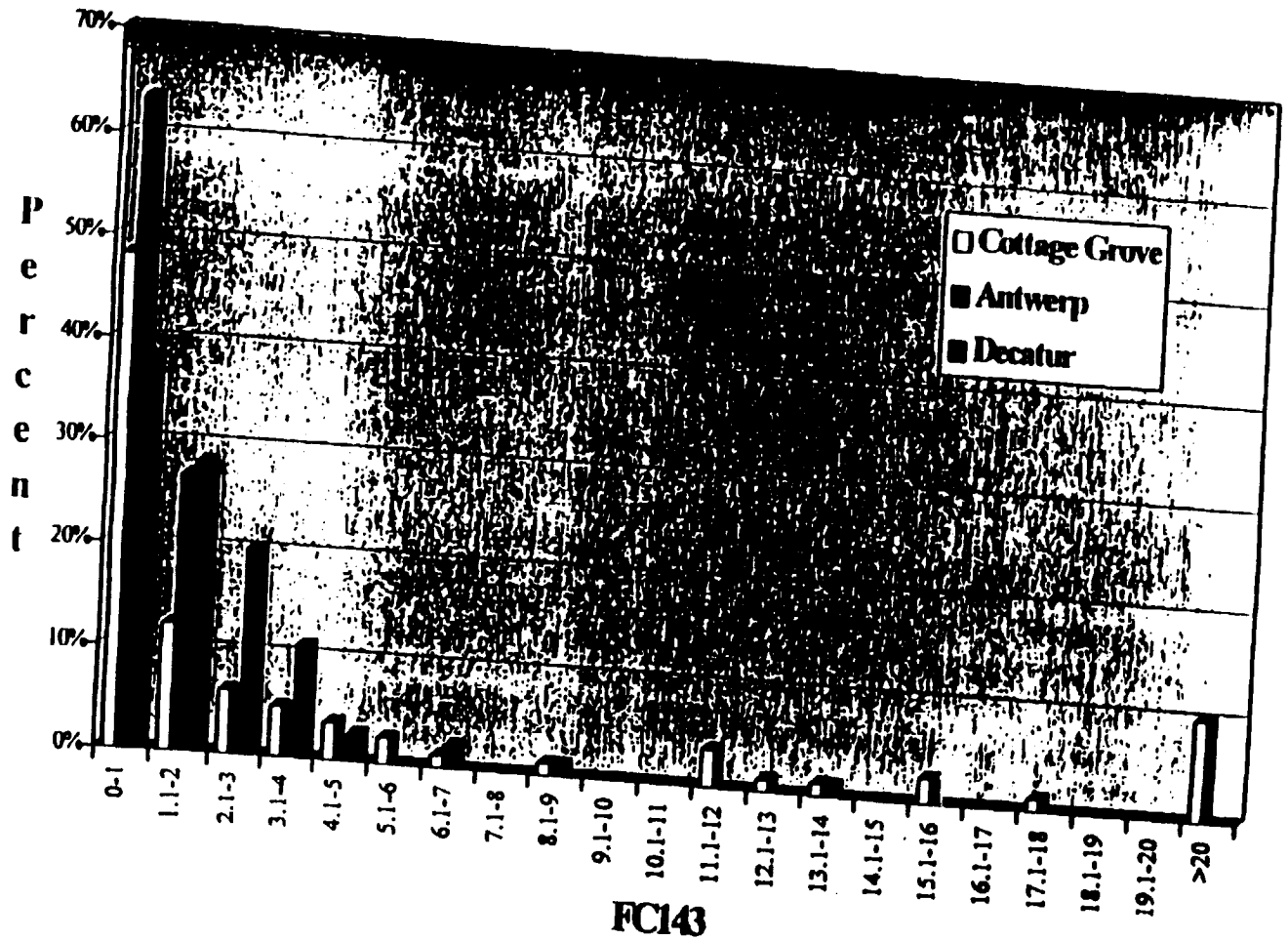


3M Medical Department
October 1995

Appendix 2

Fluorine Test Results

Distribution of FC143 Values at Three Locations: Cottage Grove-1995, Antwerp-1995, and Decatur-1994



3M Medical Department
October 1995

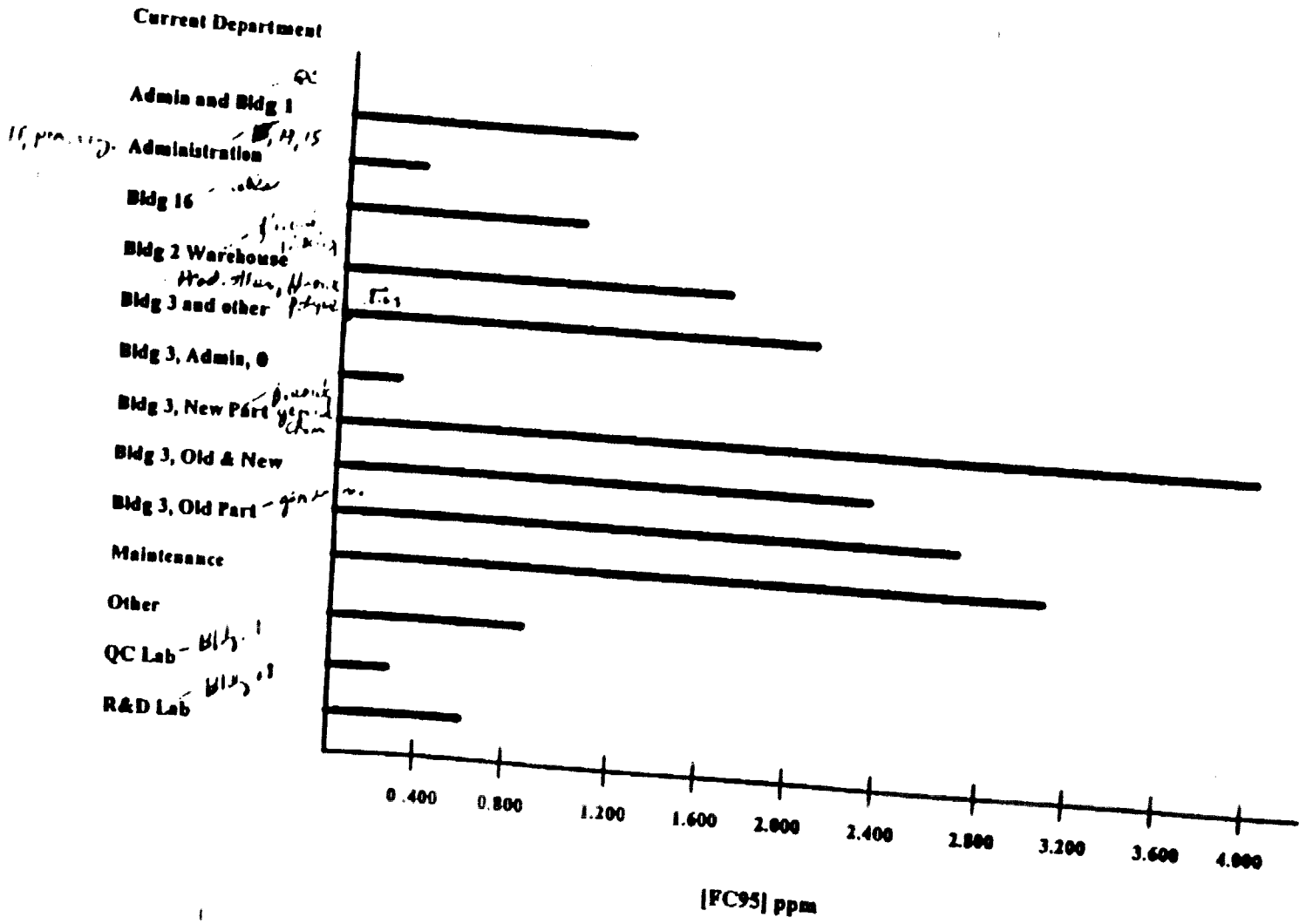
Antwerp 1995 Fluorochemical Study

Mean Values **Table 1**

Label	N	Mean	Minimum	Maximum
Age at Exam	93	36.2366	21.0000	60.0000
Years worked for 3M	93	11.8290	0.5000	27.2000
Yrs worked Bldg. 2 Warehouse	9	6.8444	0.0000	20.0000
Yrs worked Bldg. 3 old part	51	4.9882	0.0000	20.0000
Yrs worked Bldg. 3 new part	46	5.8696	0.0000	20.0000
Years worked fluoralpolymer	10	4.6080	0.0800	11.0000
Yrs worked fluoral mill	9	3.8456	0.0300	11.0000
Yrs worked maintenance	9	3.8422	0.0800	11.0000
Yrs worked administration	13	4.3769	0.9000	9.0000
Yrs worked QC lab	13	10.8077	1.0000	21.0000
Yrs worked R&D lab	11	10.1818	0.0000	20.0000
Yrs workedBldg. 16	14	8.3086	0.0700	19.0000
Yrs in current job	90	8.6633	0.5000	21.0000
Yrs in long held job	25	9.1200	1.5000	21.0000
Yrs on long held non-3M job	59	5.9059	0.2000	22.0000
Age started cigarettes	53	16.5660	13.0000	20.0000
Years smoked	51	15.4118	0.0000	35.0000
Cigarettes per day now	42	9.3929	0.0000	25.0000
Avg cigs per day over entire time smoked	52	14.2788	0.0000	30.0000
Age stopped cigarettes	22	27.9091	20.0000	40.0000
Cigarettes per day	91	4.3352	0.0000	25.0000
Age started drinking alcohol regularly	82	15.3171	1.0000	25.0000
Months ago stopped drinking alcohol	5	18.6000	0.0000	72.0000
Drinks/week when were drinking	77	11.3377	0.0000	50.0000
Drinks/week now	86	9.2006	0.0000	42.0000
Drinks per day	88	1.2845	0.0000	6.0000
FC95	93	1.8280	0.0000	9.9000
FC143	93	1.13231	0.0000	13.2000
Height	93	69.5961	62.9921	75.9843
Weight	93	163.9982	119.0700	243.0000
Body Mass Index	93	23.7609	17.9013	31.5617
Systolic blood pressure	93	125.2688	110.0000	140.0000
Diastolic blood pressure	93	78.4946	60.0000	100.0000
Alkaline Phosphatase	92	74.2391	31.0000	121.0000
Cholesterol	92	212.8587	100.0000	340.0000
Creatine	92	0.8989	0.6000	1.6000
Direct Bilirubin	92	0.2185	0.2000	0.4000
Glucose	92	81.2391	60.0000	126.0000
G G Trans	92	40.2500	12.0000	294.0000
HDL Cholesterol	92	54.8804	31.0000	97.0000
LDL Cholesterol	92	135.0587	28.5977	261.3750
SGOT	92	25.4891	13.0000	96.0000
SGPT	92	43.7391	26.0000	122.0000
Total Bilirubin	92	0.8543	0.3000	2.9000
Triglycerides	92	114.5435	34.0000	622.0000
Hematology Date	93	12942.5484	12929.0000	12950.0000
Hematocrit	93	46.6054	35.0000	51.2000
Hemoglobin	93	15.3032	11.8000	16.7000
Platelet Count	93	226.6129	132.0000	344.0000
Red Blood Cells	93	4.8804	3.7500	5.7400
White Blood Cells	93	6.3677	3.8000	13.3000

Antwerp 1995 Fluorochemical Study -- All Employees
Bar Charts by Department

Table 2



Antwerp 1995 Fluorochemical Study – All Employees
Correlations

Table 4A

	FC143	FC95	
AKPH	0.28123	0.10593	← Correlation coefficient
Alkaline Phosphatase	0.0066	0.3149	← p-value
	92	92	← number of workers
BUN	0.08329	0.01262	
	0.4299	0.9050	
	92	92	
CHOL	0.26131	0.04017	
Cholesterol	0.0119	0.7038	
	92	92	
CREA	0.01595	-0.32295	
Creatine	0.8801	0.0017	
	92	92	
DBIL	-0.11343	-0.11172	
Direct Bilirubin	0.2816	0.2890	
	92	92	
GLUC	0.04287	-0.15576	
Glucose	0.6849	0.1382	
	92	92	
GGT	0.07419	0.04351	
G G. Trans	0.4822	0.6804	
	92	92	
HDL	-0.11313	-0.21665	
HDL-Cholesterol	0.2830	0.0380	
	92	92	
LDL	0.20594	0.07286	
LDL-Cholesterol	0.0489	0.4901	
	92	92	
SGOT	0.07845	0.08180	
S G O T	0.4573	0.4382	
	92	92	
SGPT	0.06670	0.1088	
S G P T	0.5276	0.9180	
	92	92	

Antwerp 1995 Fluorochemical Study -- All Employees
Correlations

Table 4B

	FC143	FC95	
TBIL	-0.08733	-0.10720	← Correlation coefficient
Total Bilirubin	0.4078	0.3091	← p-value
	92	92	← number of workers
TRI	0.28934	0.10967	
Triglycerides	0.0052	0.2980	
	92	92	
HEMADATE	-0.15918	-0.14235	
Hematology Date	0.1275	0.6869	
	93	93	
HCT	0.03412	0.19450	
Hematocrit	0.7475	0.0617	
	93	93	
HGB	0.05441	0.16218	
Hemoglobin	0.6044	0.1204	
	93	93	
MCH	0.15546	0.22622	
	0.1368	0.0292	
	93	93	
MCHC	0.06665	-0.07479	
	0.5256	0.4762	
	93	93	
MCV	0.12296	0.25321	
	0.2403	0.0143	
	93	93	
PLCT	0.07072	-0.11574	
Platelet Count	0.5006	0.2692	
	93	93	
RBC	-0.05784	0.00350	
Red Blood Cells	0.5819	0.9734	
	93	93	
WBC	0.01226	0.24969	
White Blood Cells	0.9071	0.0158	
	93	93	

Antwerp 1995 Fluorochemical Study – Males with Hormone Testing Correlations

Table 5A

	FC143	FC95	
LH	-0.08043	0.05385	← Correlation coefficient
Luteinizing hormone	0.5787	0.7103	← p-value
	50	50	← number of workers
FSH	0.28462	0.17411	
Follicle stimulating hormone	0.0451	0.2266	
	50	50	
PROLAC	-0.18504	0.12919	
Prolactin	0.1983	0.3712	
	50	50	
TSH	0.16716	0.16702	
Thyroid stimulating hormone	0.2459	0.2463	
	50	50	
SHBG	0.08661	0.16948	
Sex hormone binding globulin	0.5498	0.2393	
	50	50	
CORRIA	-0.15447	0.10480	
Cortisol	0.2841	0.4689	
	50	50	
DHEAS	-0.11882	-0.18808	
DHEA-S	0.4112	0.1909	
	50	50	
HT	-0.15958	0.10223	
Height	0.2683	0.4799	
	50	50	
WT	-0.10880	-006983	
Weight	0.4520	0.6299	
	50	50	
BMI	-0.00231	-0.17683	
Body Mass Index	0.9873	0.2193	
	50	50	
SYSTOL	0.07163	-0.00881	
Systolic blood pressure	0.6211	0.9516	
	50	50	