U. S. Department of Health, Education, and Welfare
Public Health Service
Center for Disease Control
National Institute for Occupational Safety and Health
Cincinnati, Ohio 45226

Health Hazard Evaluation Determination
Report No. 76-73-523

Stearns and Foster Mattress Factory
Lockland and Mason Plants
Cincinnati, Ohio 45215

SEPTEMBER 1978

I. TOXICITY DETERMINATION

An environmental and medical survey was conducted on April 4-5 and 18-19, 1977, at the Stearns and Foster Mattress Company in Cincinnati, Ohio. This survey was done at both of their plants; one in Lockland and one in Mason, Ohio.

Workers in these mattress factories were exposed to cotton dust in the form of textile mill wastes and cotton linters (the short fuzz around the cotton seed). Environmental dust sampling was performed using the vertical elutriator and personal samplers (Model G battery operated type). The sampling was performed over two days in each plant. Medical testing by questionnaire and spirometry was performed on a Monday after the workers had at least a weekend away from the job site. Analysis of the data showed one worker with byssinosis by questionnaire data who also had an 11% drop in his FEV_1 over the shift. No other cases of byssinosis were noted, however, sixteen workers had a fall in their FEV_1 of $\geq$ 5% over the shift. This indicates that there was an acute broncho constrictor effect present. The small number of workers in this study and the fact that some workers wore respirators preclude definitive toxicity determination.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this report are currently available upon request from NIOSH, Division of Technical Services, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH, Publications Office, at the Cincinnati address.

Copies have been sent to:

A. Stearns and Foster Mattress Company, Cincinnati, Ohio
B. Amalgamated Clothing and Textile Workers Union, New York, NY
C. Occupational Safety and Health Administration, Washington, DC
D. National Cotton Council, Memphis, Tennessee
E. Texas Tech University, Lubbock, Texas

For the purpose of informing employees, the employer will promptly "post" this report for a period of 30 calendar days in prominent places in or near work areas.

III. INTRODUCTION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by 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.

In May 1976, NIOSH received a formal request for a health hazard evaluation concerning occupational exposure of employees to cotton dust at a mattress factory. Workers at the Stearns and Foster Mattress Company in Cincinnati, Ohio, asked NIOSH to perform a health hazard evaluation at two of their plants in Lockland and Mason, Ohio. Some of the workers exposed to cotton dust during mattress manufacturing were complaining of respiratory symptoms. Since byssinosis is a well known hazard of the cotton textile industry NIOSH was interested in evaluating the workers' symptoms.

IV. HEALTH HAZARD EVALUATION

A. Plant Process

Both the Lockland and Mason plants operate a garnett which is a machine that combines cotton linters (short fibers found close the the seed) and cotton textile mill wastes to make a cotton felt pad which can be used in mattress or upholstery construction. The workforce can be divided into three separate departments in each of these plants as follows: (1) garnett workers; (2) quilt and tape edge workers; and (3) sorting workers. The garnett workers feed the cotton products into the garnett by hand and tend the needles which sew a material to the felt pad. The felt pad is then cut and removed as it comes off the garnett as a finished product. The tape edge and quilt workers (at Stearns and Foster) built the mattresses using the cotton felt pad. The sorting workers separate the finished products and take them into storage. In both plants workers from the garnetting operations and mattress construction areas are included in the study. The Lockland plant has been in the same location since 1880; the Mason plant began production in 1972.

B. Evaluation Design

A combined total of 75 workers from both plants comprised the initial study population. Twenty-one workers were excluded because of missing or unreliable data leaving 54 workers for the final analysis. Of the total remaining, 19 were garnett workers, 19 were quilt and tape edgers, and 16 were sorters. No external control group was studied.

Environmental and medical testing was done on a Monday after the workers had at least 36 hours away from the job site. Each worker answered a modified British Medical Research Council questionnaire on respiratory disease with added questions for symptoms of byssinosis. An occupational history, height, and weight were recorded. Each worker performed spirometry both pre and post shift using a OHIO 800 waterless spirometer. At least five maximum expiratory flow volume curves were recorded pre and post shift. For analysis the largest FEV_1 and FVC were chosen regardless of the curve(s) on which they occurred. Flow rates were chosen from the curve with the largest FVC containing a peak flow within 15% of the largest peak flow. To be included in the analysis each subject had to complete a respiratory questionnaire as well as both pre and post shift spirometry. Only those subjects with at least 2 MEFV curves differing by less than 5% in FVC were used in the analysis.

Byssinosis was defined by the presence of chest tightness on the first day back to work after at least 36 hours away from the job site. Bronchitis was considered present if question C6 on the MRC questionnaire was answered affirmatively, indicating phlegm production on most days for as much as three months each year.

The subject was considered to have dyspnea if he said he had shortness of breath walking with people his own age at an ordinary pace on the level or with less exertion.

Environmental sampling was performed during the work shift. From each of the work areas, garnetting, quilting and tape edging, and sorting, both respirable and total dust samples were collected. The Lumsden Lynch Vertical elutriator (the NIOSH recommended sampling device for cotton dust) and the Model G battery operated total dust collector were used to collect respirable and total dust samples respectively.

C. Evaluation Results

The respirable and total dust analysis by job and by plant is outlined in Table I. The garnett workers in the Lockland plant were exposed to an average of 1.56 mg/m^3 respirable dust, while the garnett workers at the Mason plant were exposed to a 0.71 mg/m^3 respirable dust level. Workers in the quilting and tape departments in Lockland and Mason were exposed to 0.18 mg/m^3 and 0.17 mg/m^3 respirable dust levels respectively. Workers in the sorting department at the Lockland plant were exposed to a respirable dust level of 0.34 mg/m^3 while workers at the Mason plant were exposed to 0.11 mg/m^3 of respirable dust. It was noted by the industrial hygienist conducting the study that several, but not all, garnetters were wearing respirators. No employee in the quilting and tape departments or sorting departments were observed to be wearing respirators.

Table II shows the demographic data by job category. The garnetters are an older group with a greater mean year exposure when compared to the quilt and tape edge or sorting group. Employees in the Lockland plant had much greater mean years exposure as one would expect since the Lockland plant has been operational much longer than the Mason plant. The garnetters and the Q&TE workers in the Lockland plant had more mean pack years of smoking than their counterparts in the Mason plant, but the number of workers was too small for statistical testing.

The prevalence of byssinosis and bronchitis by job category and smoking status is shown in Table III. Only one subject had byssinosis by history and this was a garnett worker who smoked. There was no difference in the prevalence of bronchitic symptoms among the occupational groups, but the prevalence of bronchitis in each of the groups was greater among the smokers than the non or ex-smokers.

In Table IV the number of workers and the FEV_1/FVC ratio (FF) of those workers with and without at least Grade II dyspnea are compared within each job category. Grade II dyspnea is defined as shortness of breath when walking with others your own age at an ordinary pace on the level. There was no significant difference in the number of workers complaining of dyspnea between the three job categories. In each job category those workers with dyspnea according to the MRC questionnaire had no significant difference in their FF% from those without this symptom. The FEV_1/FVC ratio (FF) was no different between the three groups when either dyspneic or non-dyspneic workers were compared.

In Table V the change in volumes and flow rates over the shift between the three groups is compared after correcting for age differences. The garnett workers show a drop in the post shift FVC and FEV_1 of 0.127L and 0.117L respectively, as well as a drop in the flow rate at FEF_{50} and peak flow of 0.161 l/sec. and 0.200 l/sec. respectively. Although the garnett workers show a trend toward a greater decline in ventilatory capacity, there are no significant differences in the change in any flow rate or lung volume when the three groups are compared. The fall in the FEV_1 over the shift is statistically significant ($p < .05$) for each of the three groups individually.

Table VI compares the pre-shift FEV_1/FVC ratio (FF) and the FEV_1 to predicted between the 3 groups divided by job category and smoking status after adjustment for age. There is no significant difference in the FEV_1/FVC ratio (FF) or the FEV_1% of predicted between the groups. Predicted FEV_1 and FVC for the blacks were obtained by multiplying the predicted FEV_1 and FVC for whites by 0.88 and 0.85[9] respectively. The mean FEV_1 for the ex-smoker sorting group of 3 is low, due to one of the subjects having a value of 58% of predicted FEV_1.

Table VII compares the FEV_1/FVC ratio (FF) and the percentage of predicted FEV_1 between the workers divided into groups by change in the FEV_1 over the shift. Since some investigators feel that those workers with a fall in the FEV_1 over the shift (labelled reactors) are the ones at greater risk to develop chronic lung disease, then looking at their "pre-shift" FEV_1/FVC ratio for a chronic effect for reactors and non-reactors separately would be appropriate.

No significant difference was found in the FEV_1/FVC ratio or the percentage of predicted FEV_1 between the three groups after adjustment for age. There does seem to be a trend of a lower FEV_1 as % of predicted for the garnetters with $\geq$ 5% drop, although the numbers are not statistically significant. On further analysis, as shown in Table VII, the mean FF and %FEV_1 were compared among the 3 job categories and in those workers with and without $\geq$ 5% drop in the over-the-shift FEV_1. No significant differences were found except in the sorting workers. In the sorting group, the FF was significantly ($p < 0.05$) greater in those workers with <5% drop in FEV_1 when compared to their sorting counterparts who dropped $\geq$ 5%. The garnett workers show a difference of 6% in the mean FF when workers with $\geq$ 5% drop are compared to their counterparts with < 5% drop. However, when the age of the subjects and the within group variability is considered this difference is not statistically significant.

Those workers with a fall in the FEV_1 of at least 5% are grouped in Table VIII according to the plant in which they work. The garnetters at the Mason plant had more workers with a 5% decrement in the FEV_1 than did Lockland, while the reverse was true for the quilt and tape edge workers. However, there is no significant difference between the two plants in any of the job categories, since the number of subjects in each sub-group was small.

D. Evaluation and Discussion

The active material in cotton dust responsible for the syndrome of byssinosis is unknown. Roach and Schilling[1] found a correlation between the total dust concentration and the prevalence of byssinosis in workers in the textile industry. However, Zuskin[2] and later Merchant et al.[3] found no good correlation between byssinosis prevalence and total dust measurements. The later investigators subsequently developed and used a vertical elutriator to collect lint-free dust of an aerodynamic diameter $\leq$ 15 micrometers to develop dose response response curves for byssinosis prevalence.[4]

In our present study, we used the personal and the vertical elutriator sampler (the NIOSH recommended sampler for cotton dust) to measure both the total dust and the respirable fraction respectively. Our comments will be based on the measurements made with the vertical elutriator sampler. Dust concentrations in all departments at the Lockland plant were higher than their respective departments at the Mason plant. The sorting and quilting departments had much lower dust concentrations than the garnetting departments at both plants. (Table I). It should be noted that respirators were worn by several employees in the garnetting area during this study. Respirator usage was, however, not quantified or documented.

To look for any acute effect of cotton dust exposure the mean change in ventilatory capacity over the shift was compared between the garnetters exposed to high dust concentrations and the quilters and sorters exposed to lower dust concentrations. The garnett workers tended to have decrements in all post shift lung functions, however, ho statistically significant difference was found (table V). No correlation between changes in ventilatory capacity and dust concentration could be made.

Only one worker (a smoking garnett worker) complained of byssinosis and his symptoms were compatible with grade ½ byssinosis as graded by the respiratory questionnaire (Table III). Since this worker experienced a fall of 11% in his FEV_1 over the shift, there is objective data to support the subjective criteria for byssinosis; however, none of the other workers had any sumptoms of byssinosis on questioning and none showed a 10% fall in the FEV_1 over the shift. Of the remaining workers, fifteen had a decrement of $\geq$ 5% in their post shift FEV_1. Those workers with a >5% decrement in the ΔFEV_1 were distributed evenly over the three job categories without any correlation with job category (table VII). The finding of several workers with functional changes but without respiratory symptoms is not unusual among those exposed to cotton dust. Other investigators have suggested that the respiratory questionnaire may underestimate the true prevalence of chest tightness and that objective phsiological findings might reveal fewer false negatives.

Since some investigators feel that those workers showing symptoms of byssinosis or functional changes on spirometry are the ones most likely to develop chronic respiratory disease, we looked at the symptoms of dyspnea and chronic cough and phlegm as well as the "out of the dust" (pre shift FEV_1) ventilatory capacity of all workers.

Chronic bronchitis was found to be more prevalent among the smokers and ex-smokers in all three job categories regardless of dust concentrations (table III). Merchant, et al., and later Imbus and Suh[5], found that cigarette smoking and exposure to cotton dust were additive; however, the numbers in our study are too small to be statistically significant.

We found no difference in the FEV_1/FVC ratio (FF) among the bronchitic workers with and without at least a 5% ΔFEV_1 over the shift between the job categories. Those reactors with chronic bronchitis did not have any more impairment than their non-reacting bronchitic counterparts. Chronic effects of exposure to cotton dust might be found by looking at the workers with dyspnea (table IV). Here, the ventilatory capacity FEV_1/FVC) was compared within each category and between categories for workers with and without Grade II dyspnea to see if these workers had any chronic impairment in ventilatory capacity. No significant difference in ventilatory capacity was found among the dyspneic and non-dyspneic workers. No effect of higher dust concentrations could be found comparing the garnetters (high dust concentration) to the sorters and quilters (low dust concentrations).

To evaluate the possibility of chronic impairment of ventilatory function regardless of the ΔFEV_1, "pre shift" measurements of pulmonary function were compared between the three job categories according to smoking status. Both the FEV_1/FVC ratio (FF) and % predicted FEV_1 showed no significant difference between the three groups after adjustment for age (table VI). Chronic ventilatory function impairment was not found in the workers with $\geq$ 5% ΔFEV_1 when we compared their ventilatory capacity (out of the dust) with their counterparts who had <5% ΔFEV_1. There was no statistically significant difference in the FEV_1/FVC ratio (FF) or the % predicted FEV_1 between the three job categories after age adjustment.

More garnett workers at the Mason plant had 5% decrements in their FEV_1 although these workers were exposed to only one half the dust concentration of those workers at Lockland. This might be explained if there was a self-selection process among the Lockland garnetters having more mean years exposure (table II) and being a more hardy group. Racial differences could also be one of the factors since the proportion of blacks among the Lockland garnetters was 70% black while the proportion of blacks at the Mason plant was only 22%. Differential respirator usage may also be a possible explanation.

Although the garnett workers in both plants had exposure to much higher dust levels than workers in the other job categories, they did not show statistically significant differences in either the acute or chronic symptoms associated with cotton dust exposure. Only one worker complained of byssinosis symptoms and he was noted to have a 11% ΔFEV_1 decrement. We found no correlation between job category (concentration of dust) and the finding of byssinosis or a fall in the ventilatory capacity. The finding of functional changes (ΔFEV_1 decrements) without symptoms was uniform in all groups even though the garnett workers had 3-10 times the dust exposure of the other two job categories. There was no statistically significant evidence of chronic effects of dust exposure between job categories either in symptomatology or in respiratory impairment as measured by spirometry. Unfortunately, no unexposed control group was studied, respirator usage was not quantified and the small population size precludes drawing firm conclusions.

Simpson[6] in an Australian study of the cotton garnetting industry found a significant fall in the FEV_1 associated with exposure to high concentrations of cotton dust. His recommendations were to set the level of acceptable dust concentration at 5 mg/m^3 total dust, since below this level there was no significant fall in the FEV_1 in the group of garnetters he studied. His study of 26 workers in 6 garnetting plants was the only medical and environmental study of the garnetting industry until Curtis and Parnes[7] studied the Stearns and Foster garnetting operation in 1973. Although vertical elutriator dust samples of 3-4 mg/m^3 were measured, the workers did not show any significant change in the ventilatory capacity or admit to symptoms of byssinosis; however, there was greater than 50% prevalence of chronic bronchitis among exposed workers. They thought that the poor correlation between dust levels and changes in ventilatory capacity might be due to their small sample size, a self-selection process, or to the fact that some workers used respirators during the study.

One possible explanation for the inability to correlate the workers functional changes with dust concentrations in the garnetting industry, when compared to the textile industry maybe found in the work of Morey and Wakelyn[8]. They suggest that garnett workers are exposed to a qualitatively different type of dust than cotton textile workers, and imply that the trash associated with the garnetting process is unlikely to cause symptoms as similar dust concentrations. Materials used in garnetting are cotton linters (short fibers remaining on the seed after ginning) and textile mill or gin waste products. They found that the trash content of linters was mostly seed coat fragments. On the other hand, they argue that the textile mill wastes have already been through several mechanical operations and the more friable particles have been removed by the time the material reaches the garnett.

E. Conclusions

Although byssinosis as defined by the questionnaire was found in only one worker who had both the classical symptoms and an 11% fall in his over the shift FEV_1, the large number of workers (15) with over the shift pulmonary function changes indicate that an acute broncho constrictor effect was present even in areas where dust levels varied from 0.11 to 0.34 mg/m^3. However, no clear cut dose response relationship between dust level and biologic response can be made from our analysis. Compared with other studies in the cotton textile industry where dose response curves have been constructed our data does not appear to follow this same pattern; however, the decrements observed among quilting and sorting workers are similar to those observed in the primary textile industry at similar dust levels.[4]

Whether the lack of greater decrements among garnetters is attributable to selection occuring in a cross-sectional study, differences in the properties of dust, differential respirator usage, or simply small sample size in unknown. Because of the limited size of the population, the lack of an unexposed control group, and questions regarding selection and differential respirator usage, we conclude that no firm conclusions can be drawn from this study and no generalizations to this segment of the cotton industry should be attempted.

F. Recommendations

We would like to make the following recommendations until further studies can be done with a larger sample size to enable the development of dose response relationships in the garnetting industry.

(1) The one worker with byssinosis and an 11% drop in the post shift FEV_1 needs to be moved to another job with lower dust concentrations.

(2) Each of the additional fifteen workers who showed a $\geq$ 5% fall in the post shift FEV_1 need to have periodic follow-up with spirometry and respiratory questionnaire every six months. If their decrement in ΔFEV_1 reaches 10% or if there is a fall in the pre shift (out of the dust) FEV_1 (% of predicted) to below 80% they then need to be moved to an environment with lower dust concentrations.

(3) OSHA standards for dust exposure, work practices, and medical surveillance should be followed.

V. REFERENCES

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TABLE I

RESPIRABLE AND TOTAL DUST SAMPLES BY JOB CATEGORY

LOCKLAND PLANT	Garnett	Quilting	Sorting
VE	(Mean of 8 samples) 1.56 mg/m^3 (± 1.03)	(Mean of 8 samples) .18 mg/m^3 (± 0.12)	(Mean of 4 samples) .34 mg/m^3 (± 0.13)
ATD	(Mean of 18 samples) 2.86 mg/m^3 (± 2.25)	(Mean of 8 samples) .32 mg/m^3 (± 0.79)	(Mean of 4 samples) .50 mg/m^3 (± 0.13)

MASON PLANT	Garnett	Quilting	Sorting
VE	(Mean of 8 samples) .71 mg/m^3 (± 0.30)	(Mean of 8 samples) .17 mg/m^3 (±0.13)	(Mean of 4 samples) .11 mg/m^3 (± 0.50)
ATD	(Mean of 30 samples) 1.38 mg/m^3 (± 0.69)	(Mean of 12 samples) .36 mg/m^3 (± 0.15)	

VE - Vertical Elutriator (respirable dust)
ATD - Area Total Dust Sample
mg/m^3 - milligrams per cubic meter
(N) - Standard deviation

TABLE II

DEMOGRAPHIC DATA BY JOB CATEGORY

	GARNETT	Q-TE	SORTING
Number	19	19	16
Mean Age (years)	39	29	28
Mean Height (cm)	175	177	177
Mean Pack Years			
Smokers	14 (6)	12 (7)	3 (5)
Ex-smokers	10 (4)	6 (4)	2 (1)
Race B/W	7/3 L 2/7 M	3/4 L 0/12 M	5/4 L 0/7 M
Mean Years Exposure	13 15.3 L 9.4 M	8 11.7 L 5.2 M	5 8.0 L 2.1 M

(N) = Number of workers
(L) = Lockland
(M) = Mason
(B) = Black
(W) = White

TABLE III

PREVALENCE OF BYSSINOSIS AND CHRONIC BRONCHITIS
BY SMOKING STATUS AND JOB CATEGORY

	BRONCHITIS			BYSSINOSIS		
	Garnett*	Q+TE	Sorting	Garnett*	Q+TE	Sorting
Smokers	2/10	5/9	4/8	1/10	0/9	0/8
Non-Smokers	0/4	1/5	1/5	0/4	0/5	0/5
Ex-Smokers	2/4	2/5	1/3	0/4	0/5	0/3

*Interviewer error resulted in an undeterminable smoking status for 1 garnett worker

TABLE IV

GRADE II DYSPNEA VS. FEV_1/FVC RATIO (FF)

	MEAN FF
GARNETTS	
Dyspnea	74% (1)
Without Dyspnea	78% (18)
QUILT AND TAPE EDGE	
Dyspnea	(0)
Without Dyspnea	78% (19)
SORTING	
Dyspnea	84% (1)
Without Dyspnea	82% (15)

(N) = Number of workers

FEV_1 = Forced expiratory volume in 1 second

FVC = Forced vital capacity

TABLE V

MEAN ΔFEV_1 ΔFVC ΔFEF_{50} AND ΔPF VS. JOB CATEGORY

	ΔFVC (L)	SD	ΔFEF_1(L)	SD	(L/S) ΔFEF_{50}	SD	ΔPF	SD
GARNETT (19)	-0.127	0.286	-0.117*	0.192	-0.161	0.422	-0.200	0.921
Q & TE (19)	-0.05	0.129	-0.094*	0.130	-0.375	0.698	0.068	1.039
SORTING (16)	0.003	0.185	-0.087*	0.190	-0.107	0.590	0.181	1.154

ΔFVC = post shift FVC - pre shift FVC

ΔFEV_1 = post shift FEV_1 - pre shift FEV_1

ΔFEF_{50} = post shift FEF_{50} - pre shift FEF_{50}

ΔPF = post shift peak flow - pre shift peak flow

FEF_{50} = forced expiratory flow at 50% vital capacity

PF = peak flow

(N) = Number of workers

* = $p < .05$

SD = standard deviation

TABLE VI

MEAN PRE SHIFT FEV_1/FVC RATIO AND PERCENT OF PREDICTED FEV_1

	GARNETT		QUILT & TAPE EDGE		SORTING	
	% FEV_1	FF	% FEV_1	FF	% FEV_1	FF
Smokers	86% (10)	78% (10)	99% (9)	76% (9)	102% (8)	80% (8)
Non-Smokers	98% (4)	80% (4)	105% (5)	79% (5)	97% (5)	82% (5)
Ex-Smokers	99% (4)	83% (4)	99% (5)	77% (5)	*88% (3)	80% (3)

FF = FEV_1/FVC ratio

* one with 58% FEV_1 Predicted

%FEV_1 = Pre shift FEV_1 expressed as a % of predicted FEV_1

FEV_1 = Forced expiratory volume in 1 second

FVC = Forced vital capacity

TABLE VII

PERCENT PREDICTED FEV_1 AND FEV_1/FVC RATIO (FF)
BY THEIR OVER THE SHIFT CHANGE IN FEV_1 (ΔFEV_1)

	> 5% Increase		≤ 5% Increase		< 5% Drop		≥ 5% Drop	
	FEV_1%	FF	FEV_1%	FF	FEV_1%	FF	FEV_1%	FF
GARNETT	(1) 91%	76%	(2) 99%	78%	(9) 95%	80%	(7) 86%	74%
QUILTING	(0) -	-	(4) 98%	79%	(11) 102%	80%	(4) 97%	74%
SORTING	(1) 59%	82%	(3) 100%	82%	(7) 99%	85%*	(5) 101%	78%

FF = FEV_1/FVC Ratio

$\%FEV_1$ = Pre shift FEV_1 expressed as a % of predicted FEV_1

(N) = Number of workers

* $p < 0.05$

TABLE VIII

ΔFEV_1 DROP $\geq$ 5% IN LOCKLAND VS. MASON

	Lockland	Mason
GARNETT	2/10	5/9
QUILTING AND TAPE EDGE	3/7	1/12
SORTING	3/9	2/7