U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45226

HEALTH HAZARD EVALUATION DETERMINATION
REPORT NO. 78-84-581

HARBISON-WALKER REFRACTORIES
CLEARFIELD, PENNSYLVANIA

APRIL, 1979

I. TOXICITY DETERMINATION

NIOSH conducted a health hazard evaluation at the Harbison-Walker Refractories, Clearfield Plant on May 23-24, 1978, and July 10-14, 1978. The purpose of the evaluation was to determine whether exposures to refractory dust was causing silicosis and other lung problems alleged by employees of Plants Nos. 1 and 3.

The evaluation on May 23-24, 1978, consisted of an environmental evaluation and private, non-directed medical interviews with the employees. On July 10-14, 1978, an environmental evaluation of the work atmosphere was conducted along with an intensive medical interview, chest X-rays and pulmonary function tests.

Although the chest X-rays did not show any evidence of silicosis and pulmonary function tests showed no studywide lung defect, environmental measurements did show that in certain areas employee exposure to quartz-containing dust exceed OSHA and MSHA standards and NIOSH criteria.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this report are available 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 can be obtained from the NIOSH Publications Office at the Cincinnati address. Copies have been sent to:

a) Harbison-Walker Refractories, Clearfield Plant, Clearfield, Pennsylvania
b) Harbison-Walker Refractories, Pittsburgh, Pennsylvania
c) United Steel Workers of America Local 66
d) United Steel Workers of America Local 76
e) U.S. Department of Labor, OSHA, Region III
f) U.S. Department of Labor, MSHA, Northeastern District
g) NIOSH - Region III

For the purpose of informing the approximately 310 "affected employees," the employer shall promptly "post" for a period of 30 calendar days the Determination Report in a prominent place(s) near where exposed employees work.

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 an 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 National Institute for Occupational Safety and Health received such a request from an authorized representative of employees of Harbison-Walker Refractories, Clearfield Plant, alleging a high number of silicosis and other lung problems from exposure to dust.

IV. HEALTH HAZARD EVALUATION

A. Plant Process - Conditions of Use

This company is engaged in manufacturing refractory bricks and compounding specialty refractory cements. Sections of this plant are under the jurisdiction of the Mine Safety and Health Administration (MSHA), from the time raw materials are processed up until a liquid additive is introduced. The refractory brick manufacturing is under the jurisdiction of the Occupational Safety and Health Administration (OSHA).

Plant No. 1 consists of the tipple and specialty cement manufacturing.

Plant No. 3 consists of hand molding of specialty refractory brick and production (automated) brick manufacturing.

Clay from an adjacent surface mine is brought to the tipple area. Processing consists of crushing, drying, grinding, and blending with purchased materials. This material is then conveyed to storage bins.

From the storage bins the material may be then transported to either Plants No. 1 or 3.

The material to Plant No. 1 is transported in tote bins. These materials are blended by an automated system with either acid, creosote or water added. This material is then weighed and packaged.

Blended clays are conveyed to Plant No. 3, blended with water and either auger or hydraulic pressed into bricks. These bricks are manually dusted with silica sand, stacked on racks, dried and baked.

B. Evaluation Design

On May 23-25, 1978, Walter Chrostek, NIOSH Industrial Hygienist, Mike O'Malley, Medical Officer Trainee, Michael Donohue, Certified Physician's Assistant, Medical Section, HETAB, visited the plant. A walk-through evaluation of the

operations in Plant Nos. 1 and 3 was conducted. Non-directed medical questionnaires were administered to 88 out of a total of 294 production workers in Plant No. 1 and 3. Based on the information received and observed, a decision was made to conduct an in-depth environmental-medical evaluation.

C. Evaluation Methods

1. Environmental

On July 10-12, 1978, an evaluation of the work atmosphere was conducted utilizing pre-weighed mixed cellulose ester membrane filters and personal air samplers. Sampling rate was at approximately 1.70-1.75 liters per minute for the majority of the work day. On July 10, 1978, respirable dust samples were collected during all three shifts at dust producing operations which were being performed at that time. On the two subsequent days sampling was only performed during the day shift. These samples were subsequently analyzed for quartz and cristobalite by X-ray diffraction. NIOSH method P&CAM #109 was used with the following modifications:

(a) The filters were dissolved in tetrahydrofuran rather than ashed in a furnace.
(b) No internal standard was used.
(c) The samples were not washed while on the silver membrane filter.
(d) The standards were weighed out of FWS-B filters rather than pipetted.

The limits of detection for quartz and for cristobalite were 0.03 milligram.

A total of 30 personal respirable dust samples were collected.

2. Medical

On July 10-14, 1978, 227 people participated in the medical study. They did so because of their concern regarding their silica dust exposure. Each person completed a standard respiratory questionnaire. It included an occupational history, as well as specific symptoms known to be associated with silicosis. This questionnaire also included such information as smoking histories, outside the job dust exposure, and symptoms that individuals thought may be job related. In addition to the questionnaire standard chest X-rays, assessments of ventilatory capacity via spirometry testings, and an individual physical examination of each participant's chest was performed. A review of company medical records of these individuals was also accomplished.

In order to assure reliability of X-ray interpretation, the films were read by a NIOSH contracted radiologist with specific training in the UICC/Cincinnati classification.[1]

D. Evaluation Criteria

1. Environmental

Contaminants which may have been in the work atmosphere were sampled for, and the evaluation criteria for them will be given. Airborne exposure limits for the protection of the health of workers have been recommended or promulgated

by several sources. These limits are established at levels designed to protect workers occupationally exposed to a substance on an 8-hour day, 40-hour per week basis over a normal working lifetime. For this investigation, the criteria used to assess the degree of health hazards to workers were selected from three sources:

1) NIOSH: Criteria for a Recommended Standard....Occupational Exposure to Crystalline Silica, 1974.

2) Threshold Limit Values (TLV): Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment, 1973, Recommended by the American Conference of Governmental Industrial Hygienists (ACGIH).

3) OSHA Standard: The air contaminant standards enforced by the U.S. Department of Labor - Occupational Safety and Health Administration - as found in the Federal Register - 29 CFR 1910.1000 (Table Z-3).

	Source/Concentration*	
Substance	NIOSH[2]	MSHA (TLV)[3] & OSHA[4]
Quartz (respirable)	0.050 mg/M^3	$\frac{10 \text{ mg/M}^3}{\% \text{ SiO}_2 + 2}$

*Concentrations are reported in units of milligrams of substance per cubic meter of air sampled.

2. Medical

The compound responsible for the development of silicosis is crystalline silica (silicon dioxide). The three most common crystalline forms of free silica encountered in industry are quartz, cristobalite, and tridymite. Inhalation of microscopic silica particles into the lung leads to a fibrogenic response. This results in the production of whorls of connective tissue encasing the silica particle(s). The various stages of progression of silicosis are related to the degree of exposure to free silica, duration of exposure, duration of time retained dust reacts with lung tissues, and certain host factors.[5]

Silicosis is usually a chronic disease with symptoms developing late. It is not common for the chest X-ray to become positive before 15-20 years of exposure. A more rapid onset of disease would indicate heavier exposure because of unusual circumstances of employment (lack of protection, or work in enclosed areas), or an infectious or immulogic complication.[6]

E. Results and Discussion

1. Environmental

During the environmental evaluation conducted on July 10-12, 1978, thirty (30) environmental samples were collected in Plants Nos. 1 and 3. On July 10, 1978, all three shifts were evaluated. Due to malfunctions in the lorry cars, all operations were very limited during the following days, July 11-12, 1978.

NIOSH in the Criteria for Crystalline Silica states that a minimum total sample of 0.50 milligram of dust or a minimum free silica dust sample of 0.025 milligram is needed for accurate analysis of the collected dust. Where visual observation of the operation and collecting membrane showed dust generation and accumulation to be low, evaluations were made for two 8-hour shifts at the same operation in order to correct the above deficiency. Although the quartz content in 50 percent of the samples was below the lower limit of detection this may be attributed to the fact that 0.5 milligram or less respirable dust was collected on membrane filters and no positive identification of this substance could be made as to the quartz content. At ten operations the NIOSH criteria, OSHA and MSHA standards were exceeded (See Table I).

2. Medical

As seen in Table II, a total of 227 workers, 10 females and 217 males, participated in this health hazard evaluation. The age range was 19.2 - 65.5 years with a mean age of 39.9 years. The cumulative years of service with both range and mean years are elaborated on in Table II.

Table III details symptoms reported by the study participants. One can discern a high frequency of respiratory complaints, i.e. (wheezing 41%, breathless 45%) among the 227 respondents. Table IV deals with past medical histories, it reveals a history of pneumonia among 20% of study participants. Table V lists occupational histories. Table VI is concerned with employees who have/are working in Plant No. 1. It details that nearly one-fourth of these employees have labored in the cristobalite milling operation. Given their mean years worked (6.2), their potential for silicosis development in later years can not be dismissed. The workers of Plant No. 3 are represented by Table VII. The mean years worked in No. 3 Plant were 12.8 years. Table VIII details employees' smoking histories.

Silicotic pulmonary symptoms begin insidiously. These symptoms include shortness of breath, wheezing, coughing and consistent non-specific chest maladies. The principal symptom of established silicosis is shortness of breath. This symptom is usually associated with positive chest X-rays.

The diagnosis of silicosis depends upon historical and X-ray evidence. A history of significant exposure to free silica is required. X-ray changes provide evidence that exposure has in fact produced lung disease. Routinely, a posterior-anterior (PA) view of the chest is taken at full inspiration. Simple silicosis is present when the nodules viewed are less than 10mm in size. Complicated silicosis is present when the nodules are larger than 10mm in size. NIOSH's contracted "B-reader" found no evidence of current silicosis among the workers X-rayed on site.

Spirometry testing helps substantiate the diagnosis of silicosis. Pulmonary function tests of the workers are detailed in Table IX. The FVC (Forced Vital Capacity) is the maximal volume of air which can be exhaled forcefully after a maximal inspiration. The FEV_1 (Forced Expiratory Volume in one second) is that volume of air which can be forcibly expelled during the first second of expiration. The FEV_1/FVC (Forced Expiratory Volume in one second vs. a percent of the total FVC) is expressed as a percent of the predicted normal value for FEV.

All pulmonary function data was generated using predicted values of Knudson, et al[7]. No clear reduction of pulmonary function was discerned for the study pulmonary function testing helps substantiate the diagnosis of silicosis. No clear reduction of pulmonary function was discerned for the study participants on an overall basis. Yet, on an individual basis, dust exposure may have been a primary respiratory insult. While this dust exposure may be complicated by cigarette smoking, work histories of other dust jobs, or the individual's health status, the irritant effects of the dust can not be discounted. This irritant effect is evidence by the symptoms shown in Table III.

3. General

On July 11, 1978, in the Tipple area, during 24:00 to 07:00 period, the industrial hygienist questioned the lorry car operator as to why he did not wait until the lorry car came to a full stop. The industrial hygienist was informed that the brakes failed on both of the lorry cars. This was brought to the attention of management and operations of these vehicles were curtailed and a work order was initiated. This resulted in the curtailment of production and necessitated in evaluating two shifts on the same filter in order to obtain the minimum of contaminant for analysis.

The lorry cars are equipped with dust collectors; however, when they are activated, instead of drawing contaminated air in, they are exhausting air. This causes complaints from the employees, and they do not activate the dust collectors.

On July 11, 1978, in the Tipple area during 24:00 to 07:00 shift, a malfunction occurred rupturing the duct work in three places. This caused a dispersion of dust in the area. All operations ceased until the dust settled.

Although cleaning in some areas was done by vacuum methods, in other areas it was being performed manually.

V. RECOMMENDATIONS

Although all X-rays were negative for silicosis, pulmonary function tests and the completed questionnaires suggest that a health problem exists. This was further borne out by the results of the environmental evaluation. For the above reasons the following recommendations are made:

A. Environmental

1. Establish a periodic maintenance program on all local exhaust ventilation systems. This should include replacing ruptured ducts and cleaning out the collectors. No specific period can be recommended, however, frequency would depend on dust accumulation.

2. When performing housekeeping, it is recommended that it be done by vacuum rather than manual methods.

3. When malfunctions occur, supply and require employees to wear NIOSH approved respirators for protection against pneumoconiosis-producing dusts.

4. Although the crystobalite operation could not be evaluated since it is sporadic, this operation should be evaluated and good ventilation engineering principles should be instituted. Some of these principles were discussed with management during the evalution.

5. Utilize only pre-washed sand for sprinkling bricks.

6. Make any changes in the ventilation system necessary at the bag breaking operation to contain the dust.

B. Medical Examination

Medical examinations shall be made available to all workers subject to "exposure to free silica" prior to employee placement and at least once each 3 years thereafter. Examinations shall include as minimum:

(1) A medical and occupational history to elicit data on worker exposure to free silica and signs and symptoms of respiratory disease.

(2) A chest roentgenogram (posteroanterior 14" by 17" or 14" by 14") classified according to the 1971 ILO International Classification of Radiographs of Pneumoconises. [ILO U/C International Classification of Radiographs of Pneumoconisoese 1971, Occupational Safety and Health Series 22 (rev.) Geneva, Internation Labor Office, 1972]

(3) Pulmonary function tests including forced vital capacity (FVC) and forced expiratory volume at one second (FEV 1) to provide a baseline for evaluation of pulmonary function and to help determine the advisability of the workers using negative- or positive-pressure respirators. It should be noted that pulmonary function tests may vary significantly in various ethnic groups. For example, in black persons, the test values for the FVC should be divided by 0.85 before the percentage value is compared with normal figures.

(4) Body weight.

(5) Height.

(6) Age.

(7) Initial medical examinations for presently employed workers who did not participate in this study shall be offered within 6 months of the receipt of this report.

C. Medical Management

An employee with or without roentgenographic evidence of silicosis who has respiratory distress and/or pulmonary functional impairment should be fully evaluated by a physician qualified to advise the employee whether he should continue working in a dusty trade.

(1) These records shall be available to the medical representative of the Secretary of Health, Education, and Welfare, of the Secretary of Labor, of the employee or former employee and of the employer.

(2) Medical records shall be maintained for at least 30 years following the employee's termination of employment.

VI. REFERENCES

1. UICC Committee: "UICC/Cincinnati Classification of the Radiographic Appearances of Pneumoconioses." Chest 58:57-67 (1970).

2. NIOSH "Criteria for a Recommended Standard, Occupational Exposure to Crystalline Silica", Publication No. 75-120, 1974.

3. American Conference of Governmental Industrial Hygienists, "Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment", 1973.

4. U.S. Department of Labor, Occupational Safety and Health Administration, Federal Register, Vol. 39, No. 125, Part II, June 12, 1974, Subpart Z, Section 1910.1000, Table Z-3.

5. Stanley L. Robbins, M.D. Pathology, W.B. Saunders Company, Philadelphia, 1967

6. Morton M. Ziskin, M.D. CIBA, Occupational Pulmonary Disease Vol. 30 #4 1978.

7. The Maximal Expiratory Flow-Volume Curve, American Review of Respiratory Disease Vol. 113, 1976.

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TABLE I
HARBISON-WALKER REFRACTORIES
DIVISION OF DRESSER INDUSTRIES, INC.
CLEARFIELD, PENNSYLVANIA
JULY 10-12, 1978
HE 78-88

Airborne Concentrations of Quartz, Cristobalite and Respirable Dust Measured at the Breathing Zone

Sample Date	Sample Number		Area/Job Description	Sampling Period	Sample Volume Liters	% Quartz	% Cristobalite	Respirable Dust mg/M^3(a) Dust Level	Quartz Level (See Criteria b)
7/10/78	2656	1	Tipple Operator	0725-1425	700	9.0	LLD(c)	1.87	0.16
	2864	1	Crusher Dryer	0745-1425	726	LLD	LLD	0.24	
	2662	1	Crusher	0731-1425	753	LLD	LLD	0.44	
	2670	1	Dry Pan	0748-1422	655	LLD	LLD	0.53	
	2672	1	Screen & Conveyor	0804-1432	665	6.0	LLD	1.37	0.08
	2858	1	Lorry Car	0803-1424	653	LLD	LLD	0.47	
	2665	3	Pressman No. 7	0817-1428	610	5.0	LLD	2.39	0.11
	2660	3	Pressman No. 4	0821-1320	505	LLD	LLD	0.20	
	2659	3	Hand Molder	0755-1422	746	LLD	LLD	0.10	
7/10-11/78	2661	1	Panel Operator	1537-2233 1517-2219	1435	3.5	LLD	0.78	0.03
7/10-11/78	2654	1	Crewman Vi Pak	1550-2234 1519-2216	1396	5.9	LLD	0.49	0.03
7/10-11/78	2669	1	Fork Lift	1554-2232 1510-2222	1315	LLD	LLD	0.51	
7/10-11/78	2664	1	Bagger	1558-2231 1511-2217	1368	4.0	LLD	1.10	0.04
7/10-11/78	2655	1	Bag Breaker	1603-2245 1515-2210	1375	15.6	LLD	0.23	0.04
7/10-11/78	2674	1	Dry Pan	2320-0610	718	6.6	LLD	2.55	0.17
7/10-11/78	2848	1	Screen & Conveyor	2320-0610	615	3.7	LLD	3.06	0.11
7/10-11/78	2673	1	Gen'l Labor - Lorry Car	2400-0610	648	7.2	LLD	3.87	0.28
7/11-12/78	2855	1	Crusher Dryer	0738-1435 0814-1445	1374	LLD	LLD	0.42	

TAB (a)

HARBISON-WALKER REFRACTORIES
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Airborne Concentrations of Quartz, Cristobalite and Respirable Dust Measured at the Breathing Zone

Sample Date	Sample Number		Area/Job Description	Sampling Period	Sample Volume Liters	% Quartz	% Cristobalite	Respirable Dust mg/M^3(a) Dust Level	Quartz Level (See Critiria b)
7/11-12/78	2653	1	Dry Pan	0755-1440 0925-1441	1226	LLD	LLD	1.08	
7/11-12/78	2663	1	Crusher	0845-1436 0814-1445	1267	LLD	LLD	0.51	
7/11-12/78	2675	1	Lorry Car	0800-1450 0825-1432	1367	LLD	LLD	1.02	
7/11/78	2850	1	Screen & Conveyor	0805-1449	687	5.2	LLD	3.09	0.16
7/11/78	2658	1	Gen'l Labor	0811-1449	677	6.7	LLD	3.52	0.24
7/11-12/78	2668	3	Hand Molder	0820-1442 0835-1429	1237	13.0	LLD	0.19	0.02
7/11-12/78	2863	3	Gen'l Air No. 6 Press Area	0845-1425 0835-1445	1207	33.0	LLD	0.17	0.06
7/12/78	2849	1	Screener	0826-1436	629	LLD	LLD	2.61	
7/12/78	2657	1	Gen'l Labor	0830-1432	615	3.9	LLD	1.67	0.07
7/12/78	2867	1	Fork Lift	0807-1431	623	LLD	LLD	1.14	
7/12/78	2866	1	Bagger, Vi Pak	0811-1429	641	LLD	LLD	0.22	
7/12/78	2846	1	Bagger, Castable	0814-1430	705	LLD	LLD	0.71	

a - denotes milligrams of contaminant per cubic meter of air sampled (mg/M^3)

b - applicable Criteria

1. Occupational Health Standard promulgated by U.S. Department of Labor - Federal Register July 1, 1975, Volume 39, Title 29, Part 1910, sub-part 7, Section 1000, the silica standard for quartz in respirable dust is calculated by dividing 10 mg/M^3 by the % quartz + 2 for dust with more than 5 percent $Si\ O_2$ or 5 mg/M^3 meter for respirable dust with 1 percent or less $Si\ O_2$.
2. Occupational Health Standard promulgated by the U.S. Department of Labor, Mine Safety and Health Administration, Metal/Nonmetal Mine Safety and Health, 1973 American Conference of Governmental Industrial Hygienists, Threshold Limit Values is; respirable dust is calculated by dividing 10 mg/M^3 by the % quartz + 2 or 5 mg/M^3 for respirable dust with 1 percent or less $Si\ O_2$.
3. The NIOSH 1974 Criteria Document recommends respirable free silica exposure should not exceed 0.05 mg/M^3.

c - denotes lower limit of detection for quartz and cristobalite which was 0.03 milligrams per filter, respectively.

TABLE II

Harbison-Walker Refractories

Participants in Study		Male	Female
Total 227		217 96%	10 4%
Age Range	19.2 years	----	65.5 years
Median	39.9 years		

Cumulative years of service	# Employees	%
Unknown	9	3.97
<10 years	136	59.92
10-19 years	12	5.28
20-29 years	26	11-45
>29 years	44	19.38
TOTAL	227	100%

Range in years = .083 - 54.83 years
Median = 13.75 years

TABLE III

Harbison-Walker Refractories

Reported Symptoms

Employee	Symptoms	227 respondents
Cough:	#	%
Morning	75	33%
In Winter	74	32%
For 3 mos./yr.	59	26%
Phlegm:		
Morning	90	39%
In Winter	87	38%
For 3 mos./yr.	63	28%
Breathlessness:		
Walking uphill	102	45%
Walking level ground	43	19%
Wheezing:		
Chest ever wheezy	93	41%
Most days and nights	51	22%
Short of breath with wheezing	46	20%

TABLE IV

Harbison-Walker Refractories

PAST MEDICAL HISTORY

225 respondents

	#	%
chest injury	12	5.3%
heart trouble	18	8.0%
bronchitis	18	8.0%
pneumonia	45	20.0%
pleurisy	16	7.1%
T.B.	1	.4%
asthma	15	6.6%
emphysema	8	3.5%
Bronchiectasis	0	0

TABLE V

Harbison-Walker Refractories

OCCUPATIONAL HISTORY

Work Locations	#	% of total
Mine	36	15.8
Quarry	8	3.5
Foundry	5	2.2
Pottery	0	0
Cotton	4	1.7
Asbestos	17	7.4
Dusty job	45	20

TABLE VI

Harbison-Walker Refractories

Employees who have ever worked in Plant #1

TOTAL 103

Work Area	# persons	% of total
cristobalite	25	24.3
Pew-Seal	40	38.8
Penn. Calcine	36	34.9
ViPak	33	32.3
Dry Pac	21	20.3

Cumulative years of service	# persons	% of total
Unknown	13	12.6
<5 years	58	56.4
5-10 years	11	10.6
10-15 years	2	1.9
>15 years	19	18.4
TOTAL	103	100%

Mean # of years worked in Plant #1 = 6.2 years

TABLE VII

Harbison-Walker Refractories

Employees who have ever worked in Plant #3

TOTAL 177

Work Area	#	% of total
Grinding floors	104	58.75
Brick Production	136	76.83
Burnt Brick	75	42.37
Kilns	59	33.33

Cumulative years service		
Unknown	17	9.60
<5 years	78	44.06
5-10 years	29	16.38
10-15 years	8	4.51
>15 years	45	25.42
TOTAL	177	100%

Mean # of years worked in Plant #3 = 12.8 years

TABLE VIII

Harbison-Walker Refractories

SMOKING HISTORY

Cumulative consumption	# of smokers	%
non-smokers	72	31.71
<10 pack years	55	24.22
10-19 pack years	33	14.53
20-29 pack years	19	8.37
30-39 pack years	13	5.72
>39 years	35	15.41
TOTAL	227	100%

Cigarette smokers	#	% of total
not responding	6	2.64
current smoker	91	40.08
former smoker	87	38.32
non-smoker	43	18.94
TOTAL	227	100%

*TABLE IX

Harbison-Walker Refactories

PULMONARY FUNCTION DATA

SMOKERS VS. NON-SMOKERS

Smokers			Non-Smokers		
FVC	-	100.2	FVC	-	103.0
FEV_1	-	93.4	FEV_1	-	97.3
FEV_1/FVC	-	79.8	FEV_1/FVC	-	81.1

*All figures shown are mean values and are % predicted based on Knudson, et al.