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MOVABLE-WALL COKE OVEN TESTS OF COAL SAMPLES
SUBMITTED BY DOFASCO INC., HAMILTON, ONTARIO

Project No. 03-3-0/9-29
Job No. 3442R

J.G. Jorgensen and T.A. Lloyd
Energy Research Laboratories

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MOVABLE-WALL COKE OVEN TESTS OF COAL SAMPLES
SUBMITTED BY DOFASCO INC., HAMILTON, ONTARIO
INVESTIGATION NO. 29

by

J.G. Jorgensen* and T.A. Lloyd**

ABSTRACT

This report covers Investigation No. 29 in the continuing program of coal evaluations for Dofasco Inc., Hamilton, Ontario by the Energy Research Laboratories.

The scope of the investigation comprises technical-scale carbonization tests relevant to the understanding of the quality of the coals under review.

Purchase Order No. T-53509-10 dated August 22, 1983 and No. T-57023 dated August 30, 1983 from the company specified the following mixes must be run in duplicate:

- #128 - 25% Coal "E", 35% Coal "A", 40% Coal "B"
- #129 - 25% Coal "L", 40% Coal "A", 35% Coal "J"
- #130 - 25% Coal "M", 53% Coal "B", 20% Coal "F", 2% Coal "1A"
- #131 - 25% Coal "M", 50% Coal "B", 20% Coal "F", 5% Coal "1A"
- #132 - 25% Coal "E", 33% Coal "A", 40% Coal "B", 2% Coal "1A"
- #133 - 25% Coal "E", 30% Coal "A", 40% Coal "B", 5% Coal "1A"
- #134 - 25% Coal "L", 40% Coal "A", 33% Coal "J", 2% Coal "1A"
- #135 - 25% Coal "L", 40% Coal "A", 30% Coal "J", 5% Coal "1A"

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ESSAIS CONDUITS DANS UN FOUR A COKE A PAROIS MOBILES
SUR DES ECHANTILLONS DE HOUILLE SOUMIS PAR LA DOFASCO
INC., HAMILTON, ONTARIO
ETUDE n° 29

par

J.G. Jorgensen* et T.A. Lloyd**

RÉSUMÉ

Le présent rapport couvre l'étude n° 29, dans le cadre du programme continu d'évaluation des charbons par les Laboratoires de recherche sur l'énergie pour le compte de la Dofasco Inc. de Hamilton en Ontario.

Dans cette étude, sont faits des essais de carbonisation en grandeur réelle, pour mieux définir la qualité des charbons examinés.

Dans l'ordre d'achat n° T-53509-10 daté du 22 août 1983 et n° T-57023 daté du 30 août 1983 donné par la compagnie, était spécifié que les mélanges suivants soient pris en double exemplaire.

- Mélange n° 128 - 25% Charbon "E", 35% Charbon "A", 40%
Charbon "B"
- Mélange n° 129 - 25% Charbon "L", 40% Charbon "A", 35%
Charbon "J"
- Mélange n° 130 - 25% Charbon "M", 53% Charbon "B", 20%
Charbon "F", 2% Charbon "1A"
- Mélange n° 131 - 25% Charbon "M", 50% Charbon "B", 20%
Charbon "F", 5% Charbon "1A"

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Mélange n° 132 - 25% Charbon "E", 33% Charbon "A", 40%
Charbon "B", 2% Charbon "1A"

Mélange n° 133 - 25% Charbon "E", 30% Charbon "A", 40%
Charbon "B", 5% Charbon "1A"

Mélange n° 134 - 25% Charbon "L", 40% Charbon "A", 33%
Charbon "J", 2% Charbon "1A"

Mélange n° 135 - 25% Charbon "L", 40% Charbon "A", 30%
Charbon "J", 5% Charbon "1A"

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INTRODUCTION

The evaluation of coals for use at the coke plant at Dofaso Inc., Hamilton, Ontario is a continuing project whereby periodic investigations are carried out as requested by the company.

This report deals with Investigation No. 29 in the project series and includes evaluation data on coals as specified in Dofasco Purchase Order No. T-53509-10 dated August 22, 1983 and No. T-57023 dated August 30, 1983.

The data presented herein include the results of the carbonization tests in the CANMET movable-wall oven No. 12-71. The coke oven tests were conducted from September 20 to October 27, 1983.

Owing to the urgent need of the test results, pertinent data were orally given to Dofasco during the course of the investigation.

DETAILS OF INVESTIGATION

Sample procurement for the test program was arranged by Dofasco.

The samples were crushed in the pilot-plant hammer mill to approximately 80% minus 3.18 mm.

The following charges were carbonized in the movable-wall test oven, as specified in Dofasco Purchase Order No. T-53509-10 and No. T-57023 (the MW test oven numbers are given in parenthesis):

Mix No. 128 (MW Oven Test Nos. 1035, 1036)

25% Coal E, 35% Coal A, 40% Coal B

Mix No. 129 (MW Oven Test Nos. 1037, 1038)

25% Coal L, 40% Coal A, 35% Coal J

Mix No. 130 (MW Oven Test Nos. 1039, 1040)

25% Coal M, 53% Coal B, 20% Coal F, 2% Coal 1A

Mix No. 131 (MW Oven Test Nos. 1046, 1049)

25% Coal M, 50% Coal B, 20% Coal F, 5% Coal 1A

Mix No. 132 (MW Oven Test Nos. 1041, 1043)

25% Coal E, 33% Coal A, 40% Coal B, 2% Coal 1A

Mix No. 133 (MW Oven Test Nos. 1047, 1050)

25% Coal E, 30% Coal A, 40% Coal B, 5% Coal 1A

Mix No. 134 (MW Oven Test Nos. 1042, 1044)

25% Coal L, 40% Coal A, 33% Coal J, 2% Coal 1A

Mix No. 135 (MW Oven Test Nos. 1048, 1051)

25% Coal L, 40% Coal A, 30% Coal J, 5% Coal 1A

Coals for the coke oven charge were thoroughly mixed in a twin shell tumble blender. The prepared charges were air dried before carbonizing to a moisture level of 3%.

The prepared coal charges were carbonized in the CANMET 310 mm wide movable-wall coke oven and the cokes produced were evaluated by standard methods of testing*. The conditions of carbonization and the coke quality evaluations are given in Tables 1 to 6. The pressures developed during the coking cycles in the tests are shown graphically in Fig. 1 to 16. The values plotted are corrected for preload and thermal brick expansion.

* A schematic drawing, description and experimental procedure for the CANMET movable-wall coke oven were given in a previous Dofasco Investigation Report.

Table 1 - Carbonization conditions

Test identification number	1035	1036	1037	1038	1039	1040
Date of test	20/09/83	21/09/83	22/09/83	27/09/83	28/09/83	29/09/83
Coke oven identification.....	12-71	12-71	12-71	12-71	12-71	12-71
Description.....	Mix #128	Mix #128	Mix #129	Mix #129	Mix #130	Mix #130
	25% "E"	25% "E"	25% "L"	25% "L"	25% "M"	25% "M"
	35% "A"	35% "A"	40% "A"	40% "A"	53% "B"	53% "B"
	40% "B"	40% "B"	35% "J"	35% "J"	20% "F"	20% "F"
					2% "1A"	2% "1A"
<u>Charge Properties</u>						
Proximate analysis (db) Ash.....%						
Volatile matter%						
Fixed carbon.....%						
Moisture in charge	3.0	3.1	3.0	2.9	3.1	3.0
Minus 3.35 mm	84.4	84.4	84.6	84.6	85.4	85.4
Other						
.....						
<u>Carbonization conditions</u>						
Net weight of charge (wet).....kg	281.3	282.1	278.0	281.7	273.2	278.1
ASTM cone bulk density (wet).....kg/m ³	816.9	808.9	792.9	800.9	792.9	800.9
Calc. charge dry bulk density in oven... kg/m ³	828.2	829.8	818.5	831.4	804.1	818.5
<u>Carbonization Results</u>						
Gross coking time (at Push).....h:min	10:40	10:35	10:10	10:15	9:55	10:20
Final centre temp.....°C	1050	1050	1045	1050	1048	1050
Time to 900°C centre temp..... h:min	9:33	9:27	9:10	9:15	8:40	9:05
Time to 950°C centre temp..... h:min	9:47	9:37	9:20	9:26	8:53	9:16
Time to 1000°C centre temp..... h:min	10:08	9:56	9:39	9:44	9:07	9:38
Maximum wall pressure.....kPa	24.13	14.75	12.55	16.82	7.24	10.14
Coke yield actual	74.0	74.2	74.4	74.3	74.7	74.9

Table 2 - Coke properties

Test identification number.....	1035	1036	1037	1038	1039	1040
<u>Screen analysis of coke</u>						
(cum. % retained on)						
100 mm sieve.....%	0.0	0.2	0.3	0.3	0.9	0.8
75 mm sieve.....%	7.1	7.9	10.1	8.2	11.9	12.4
50 mm sieve.....%	54.3	56.0	58.4	54.0	60.2	61.9
37.5 mm sieve.....%	82.0	82.7	81.8	80.8	85.1	84.8
25.0 mm sieve.....%	95.0	95.0	94.8	94.6	95.2	95.6
19.0 mm sieve.....%	96.4	96.3	96.3	96.0	96.4	96.7
12.5 mm sieve.....%	97.2	97.2	97.2	96.9	97.2	97.5
Total -12.5 mm (breeze).....%	2.8	2.8	2.8	3.1	2.8	2.5
Mean coke size.....mm	53.3	54.1	54.9	53.3	56.4	56.9
<u>Coke chemical analysis</u>						
Proximate analysis (db)						
Ash.....%						4
Volatile matter.....%						
Fixed carbon.....%						
Sulphur (db).....%						
Coke apparent specific gravity.....	0.910	0.897	0.895	0.898	0.886	0.890
<u>ASTM coke tumbler test</u>						
Stability factor (cum. % + 25.0 mm).	59.6	59.6	56.4	57.2	58.3	59.8
Hardness factor (cum. % + 6.3 mm).	68.1	69.2	66.4	67.0	67.8	68.6
<u>JIS coke tumbler test</u>						
(cum. % retained on)						
30 revs: 50 mm sieve.....%	15.0	26.4	22.2	18.2	18.5	26.4
25 mm sieve.....%	88.2	88.8	88.4	89.2	89.8	90.3
15 mm sieve.....%	93.5	94.4	93.2	94.1	94.4	94.6
150 revs: 50 mm sieve.....%	2.7	5.7	4.5	6.1	5.9	10.0
25 mm sieve.....%	73.3	73.8	72.7	74.0	76.1	75.6
15 mm sieve.....%	83.0	83.2	82.2	83.5	84.3	84.3

Table 3 - Carbonization conditions

	1046	1049	1041	1043	1047	1050
Test identification number	1046	1049	1041	1043	1047	1050
Date of test	18/10/83	25/10/83	04/10/83	06/10/83	19/10/83	26/10/83
Coke oven identification.....	12-71	12-71	12-71	12-71	12-71	12-71
Description.....	Mix #131	Mix #131	Mix #132	Mix #132	Mix #133	Mix #133
	25% "M"	25% "M"	25% "E"	25% "E"	25% "E"	25% "E"
	50% "B"	50% "B"	33% "A"	33% "A"	30% "A"	30% "A"
	20% "F"	20% "F"	40% "B"	40% "B"	40% "B"	40% "B"
	5% "1A"	5% "1A"	2% "1A"	2% "1A"	5% "1A"	5% "1A"
<u>Charge Properties</u>						
Proximate analysis (db) Ash.....%						
Volatile matter%						
Fixed carbon.....%						
Moisture in charge	3.0	2.9	3.1	3.1	3.0	3.0
Minus 3.35 mm	86.9	86.9	85.8	85.8	85.2	85.2
Other						
.....						
<u>Carbonization conditions</u>						
Net weight of charge (wet).....kg	286.1	288.0	273.2	280.1	290.3	284.1
ASTM cone bulk density (wet).....kg/m ³	802.5	804.1	797.7	800.9	800.9	802.5
Calc. charge dry bulk density in oven... kg/m ³	842.6	849.0	804.1	823.3	855.4	836.2
<u>Carbonization Results</u>						
Gross coking time (at Push).....h:min	10:20	10:20	10:15	10:20	10:55	10:15
Final centre temp.....°C	1042	1042	1046	1048	1055	1043
Time to 900°C centre temp..... h:min	9:06	9:05	9:07	9:08	9:25	9:09
Time to 950°C centre temp..... h:min	9:20	9:17	9:18	9:20	9:39	9:23
Time to 1000°C centre temp..... h:min	9:46	9:38	9:38	9:40	9:58	9:43
Maximum wall pressure.....kPa	16.34	9.79	12.41	13.17	21.93	12.27
Coke yield actual	76.8	75.4	74.7	75.5	76.4	75.6

Table 4 - Coke properties

Test identification number.....	1046	1049	1041	1043	1047	1050	
<u>Screen analysis of coke</u>							
(cum. % retained on)							
100 mm sieve.....%	3.8	3.6	0.8	0.5	2.0	1.0	
75 mm sieve.....%	19.4	18.6	13.2	10.6	18.1	18.4	
50 mm sieve.....%	65.0	64.3	59.5	56.2	64.6	65.3	
37.5 mm sieve.....%	86.0	84.0	84.7	82.7	85.6	85.4	
25.0 mm sieve.....%	95.3	95.2	95.3	94.6	95.6	95.1	
19.0 mm sieve.....%	96.5	96.3	96.6	95.8	96.8	96.4	
12.5 mm sieve.....%	97.1	97.1	97.2	96.7	97.4	97.1	
Total -12.5 mm (breeze).....%	2.9	2.9	2.8	3.3	2.6	2.9	
Mean coke size.....mm	59.9	59.4	56.4	54.2	59.2	58.9	
<u>Coke chemical analysis</u>							
Proximate analysis (db)							
Ash.....%							
Volatile matter.....%							
Fixed carbon.....%							
Sulphur (db).....%							
Coke apparent specific gravity.....	0.936	0.934	0.899	0.895	0.922	0.920	
<u>ASTM coke tumbler test</u>							
Stability factor (cum. % + 25.0 mm).	59.9	59.4	59.1	58.4	61.3	58.2	
Hardness factor (cum. % + 6.3 mm).	68.8	68.5	67.2	66.7	69.7	67.2	
<u>JIS coke tumbler test</u>							
(cum. % retained on)							
30 revs:	50 mm sieve.....%	25.4	33.3	26.4	27.5	18.5	18.8
	25 mm sieve.....%	90.3	90.0	91.4	90.2	89.7	89.9
	15 mm sieve.....%	94.4	94.4	94.5	94.9	94.7	94.1
150 revs:	50 mm sieve.....%	12.2	13.4	8.8	8.0	5.7	6.1
	25 mm sieve.....%	74.7	75.9	77.0	76.4	73.4	76.5
	15 mm sieve.....%	83.5	83.9	83.8	83.9	84.5	83.7

Table 5 - Carbonization conditions

	1042	1044	1048	1051
Test identification number	1042	1044	1048	1051
Date of test	05/10/83	12/10/83	20/10/83	27/10/83
Coke oven identification.....	12-71	12-71	12-71	12-71
Description.....	Mix #134	Mix #134	Mix #135	Mix #135
	25% "L"	25% "L"	25% "L"	25% "L"
	40% "A"	40% "A"	40% "A"	40% "A"
	33% "J"	33% "J"	30% "J"	30% "J"
	2% "1A"	2% "1A"	5% "1A"	5% "1A"
<u>Charge Properties</u>				
Proximate analysis (db) Ash.....%				
Volatile matter%				
Fixed carbon.....%				
Moisture in charge	3.0	3.0	2.9	2.9
Minus 3.35 mm	83.2	83.2	86.4	86.4
Other				
.....				
<u>Carbonization conditions</u>				
Net weight of charge (wet).....kg	278.8	284.3	286.6	290.3
ASTM cone bulk density (wet).....kg/m ³	800.9	797.7	802.5	804.1
Calc. charge dry bulk density in oven... kg/m ³	821.7	837.8	845.8	855.4
<u>Carbonization Results</u>				
Gross coking time (at Push).....h:min	10:05	10:50	10:25	10:25
Final centre temp.....°C	1048	1063	1042	1047
Time to 900°C centre temp..... h:min	9:03	9:13	9:19	9:12
Time to 950°C centre temp..... h:min	9:15	9:28	9:33	9:25
Time to 1000°C centre temp..... h:min	9:34	9:49	9:54	9:45
Maximum wall pressure.....kPa	8.00	11.45	19.65	16.06
Coke yield actual	75.0	75.0	75.6	75.9

Table 6 - Coke properties

Test identification number.....	1042	1044	1048	1051
<u>Screen analysis of coke</u> (cum. % retained on)				
100 mm sieve.....%	0.3	1.2	1.8	3.0
75 mm sieve.....%	11.0	10.4	19.6	19.7
50 mm sieve.....%	59.0	57.9	68.5	63.1
37.5 mm sieve.....%	82.5	81.9	84.9	83.7
25.0 mm sieve.....%	94.2	95.0	95.1	95.1
19.0 mm sieve.....%	95.6	96.4	96.3	96.3
12.5 mm sieve.....%	96.6	97.3	97.2	97.2
Total -12.5 mm (breeze).....%	3.4	2.7	2.8	2.8
Mean coke size.....mm	55.1	55.1	59.9	59.2
<u>Coke chemical analysis</u>				
Proximate analysis (db)				
Ash.....%				
Volatile matter.....%				
Fixed carbon.....%				
Sulphur (db).....%				
Coke apparent specific gravity.....	0.899	0.904	0.930	0.929
<u>ASTM coke tumbler test</u>				
Stability factor (cum. % + 25.0 mm).	57.1	59.1	56.7	58.6
Hardness factor (cum. % + 6.3 mm).	66.6	68.2	67.2	67.3
<u>JIS coke tumbler test</u> (cum. % retained on)				
30 revs: 50 mm sieve.....%	33.8	29.8	38.4	34.0
25 mm sieve.....%	90.2	88.0	90.2	88.8
15 mm sieve.....%	94.5	93.7	94.1	93.5
150 revs: 50 mm sieve.....%	8.2	6.6	15.2	9.8
25 mm sieve.....%	75.3	73.1	76.3	71.7
15 mm sieve.....%	82.9	82.2	82.9	82.0

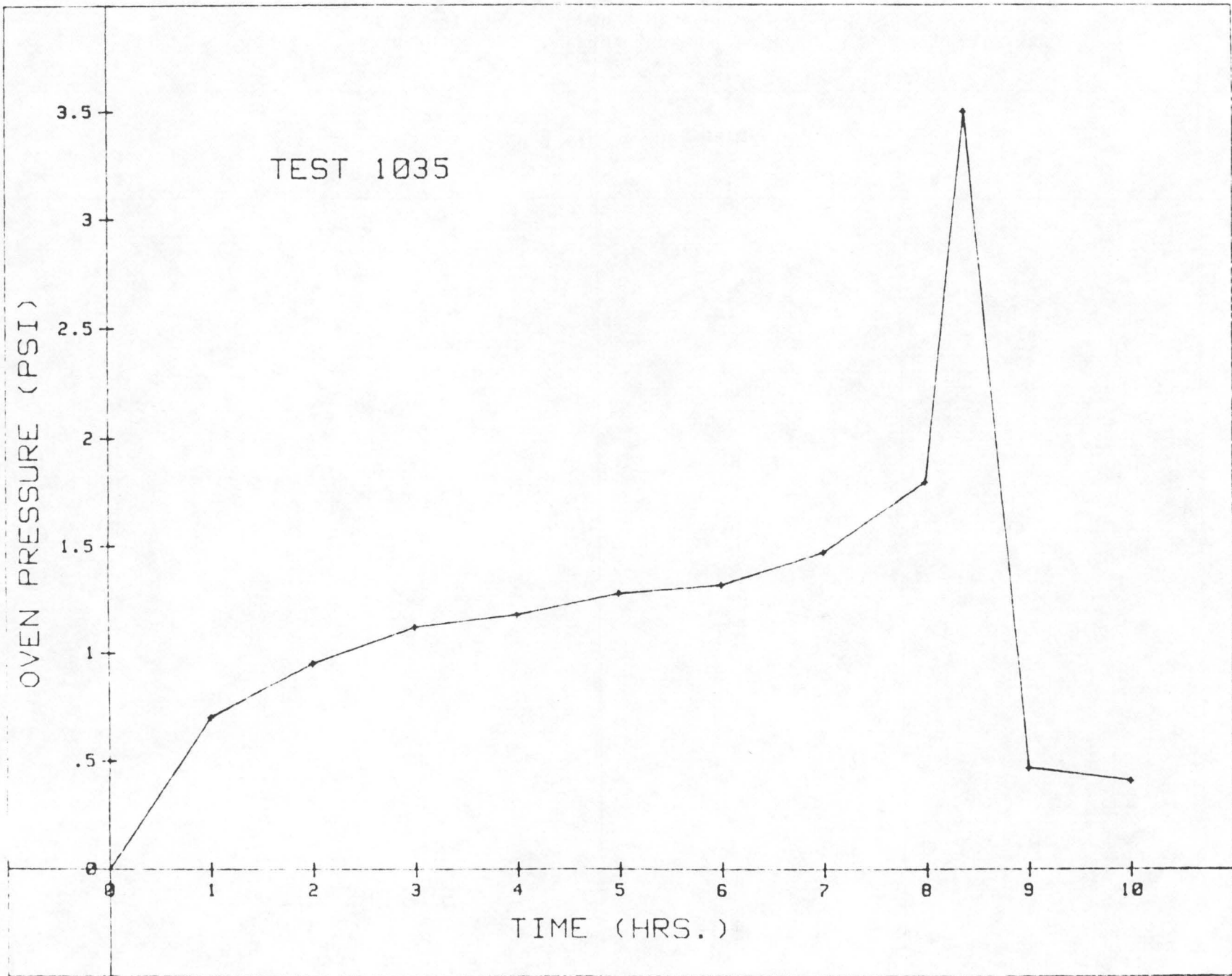


Fig. 1 - Relationship between wall pressure and hours after charging in CANMET MW coke oven (DOFASCO Mix No. 128, Test No. 1035)

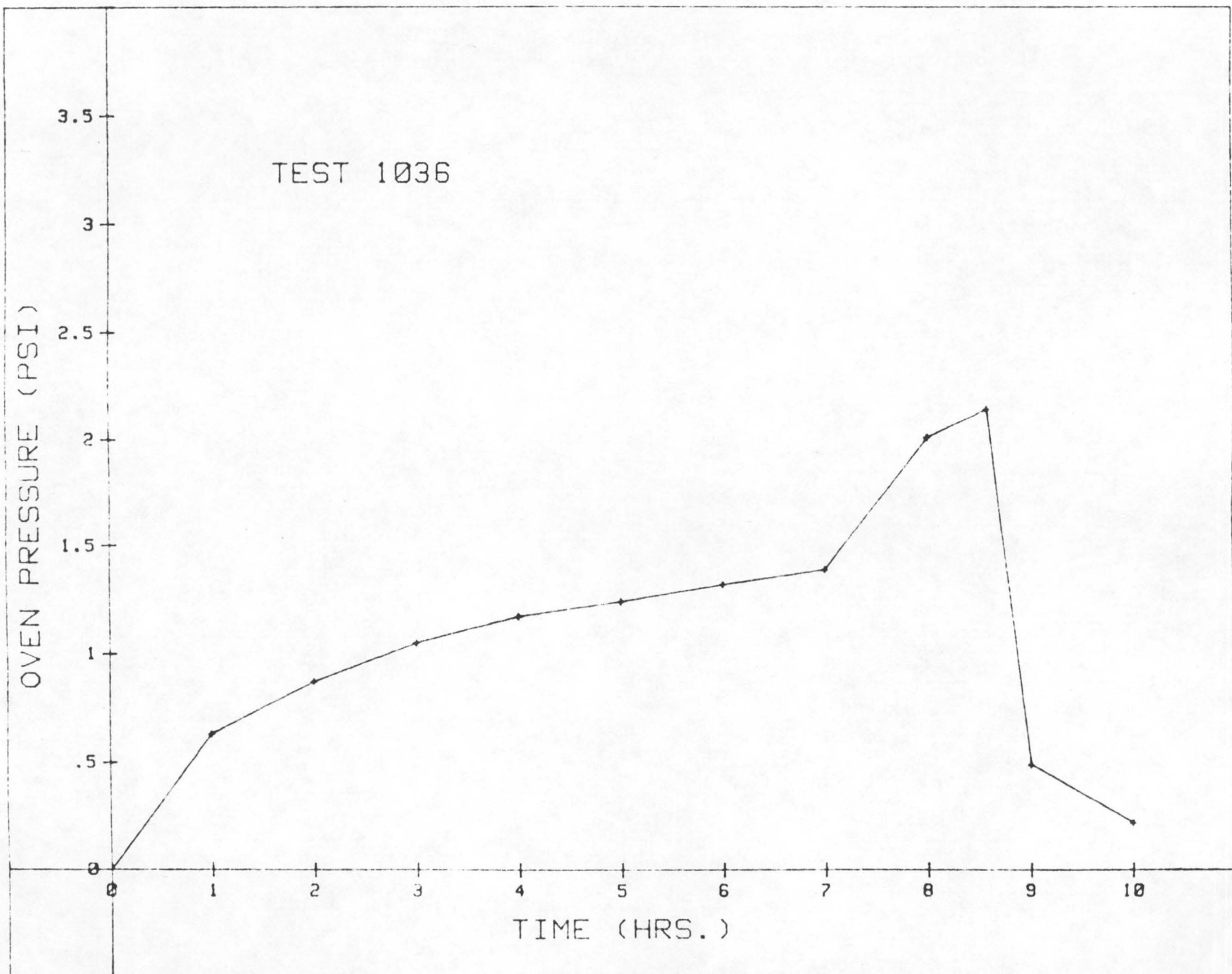


Fig. 2 - Relationship between wall pressure and hours after charging in CANMET MW coke oven (DOFASCO Mix No. 128, Test No. 1036)

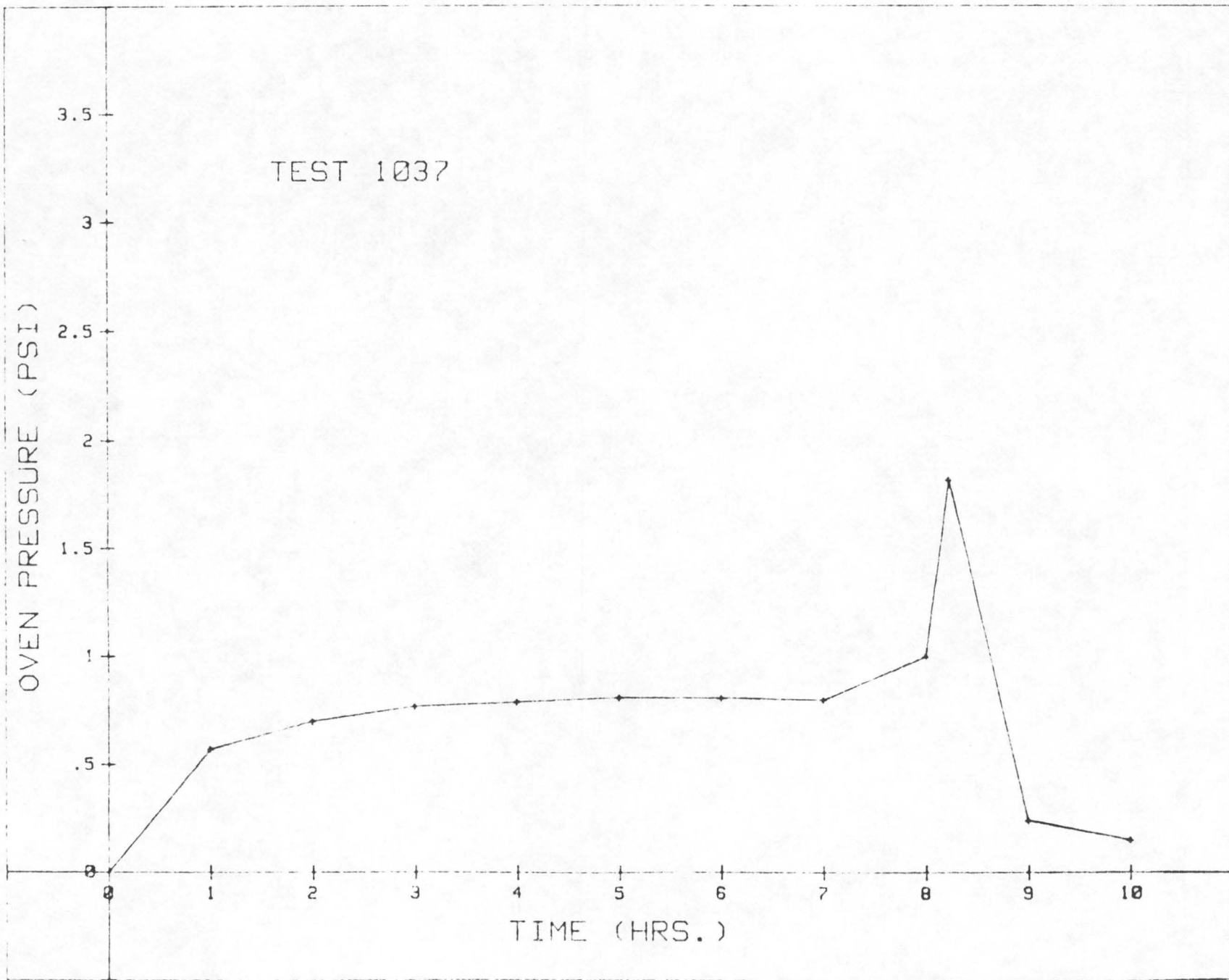


Fig. 3 - Relationship between wall pressure and hours after charging in CANMET MW coke oven (DOFASCO Mix No. 129, Test No. 1037)

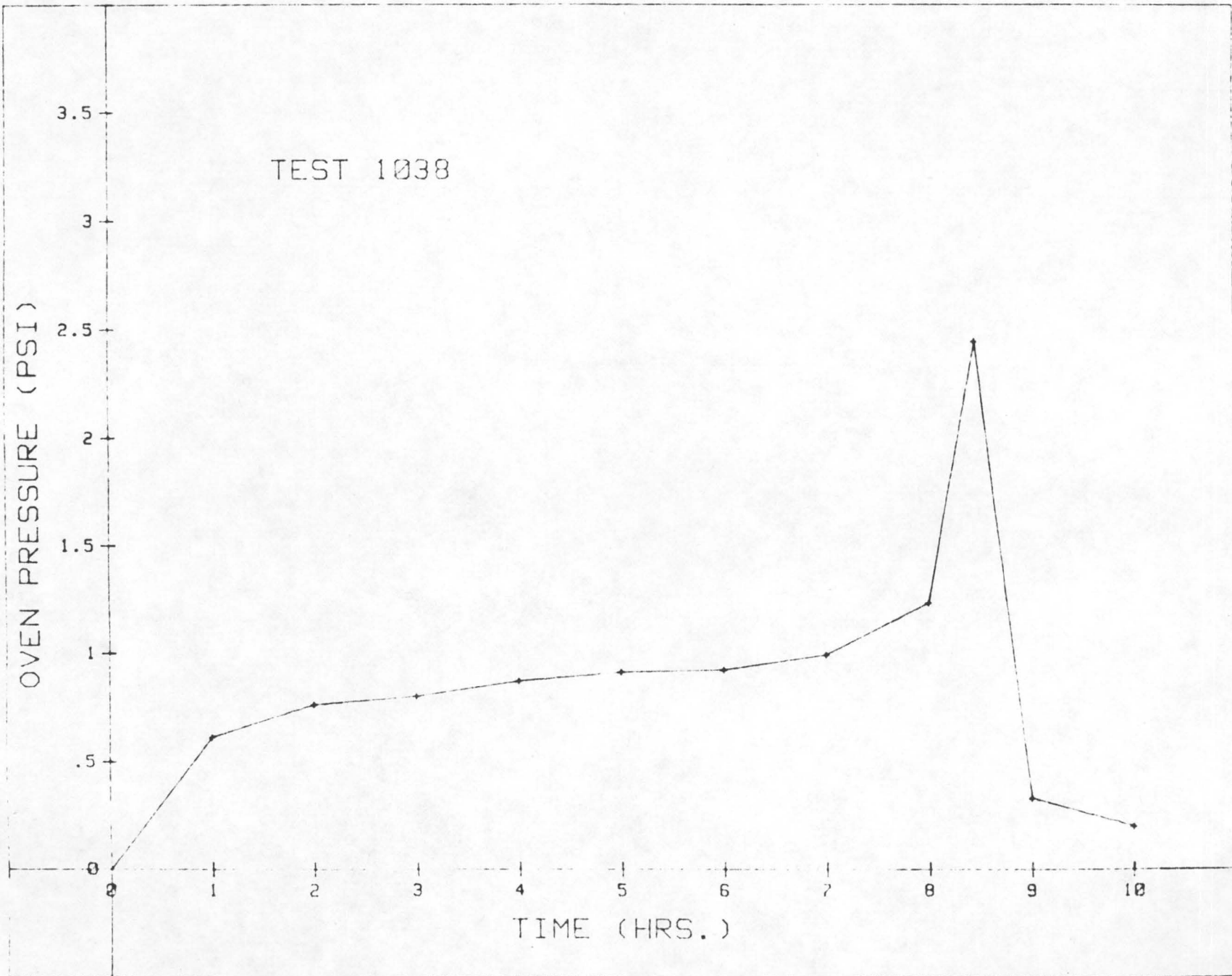


Fig. 4 - Relationship between wall pressure and hours after charging in CANMET MW coke oven (DOFASCO Mix No. 129, Test No. 1038)

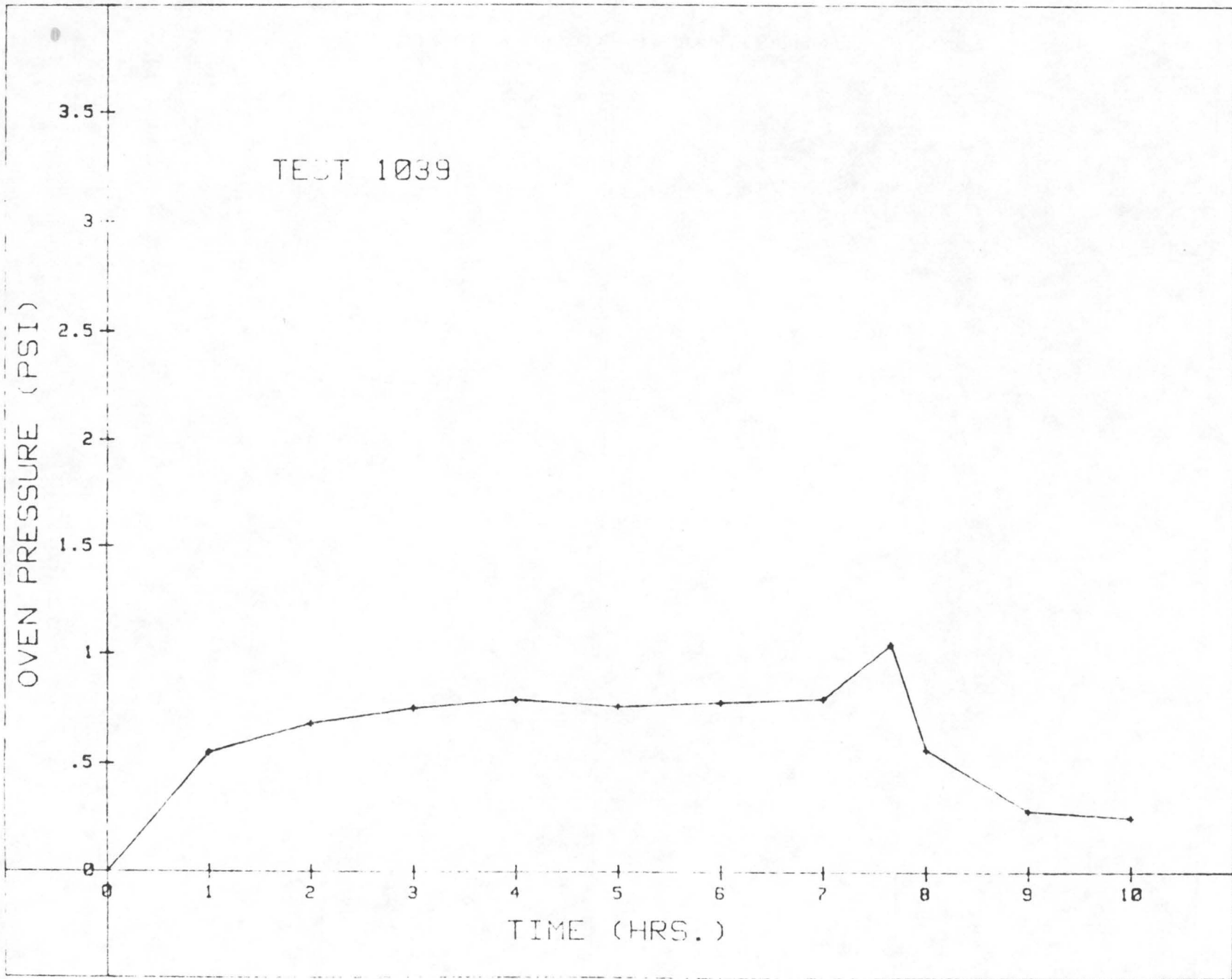


Fig. 5 - Relationship between wall pressure and hours after charging in CANMET MW coke oven (DOFASCO Mix No. 130, Test No. 1039)

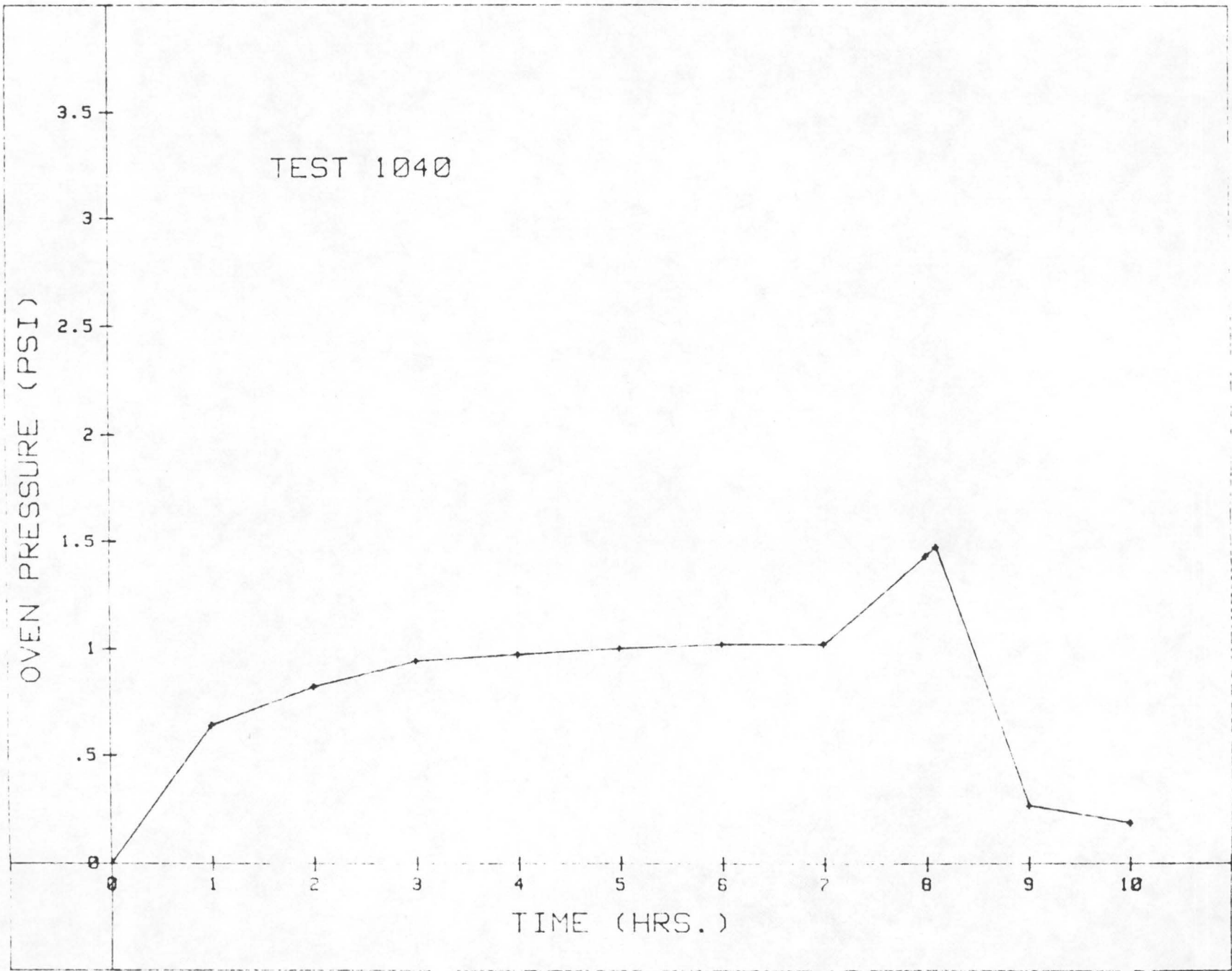


Fig. 6 - Relationship between wall pressure and hours after charging in CANMET MW coke oven (DOFASCO Mix No. 130, Test No. 1040)

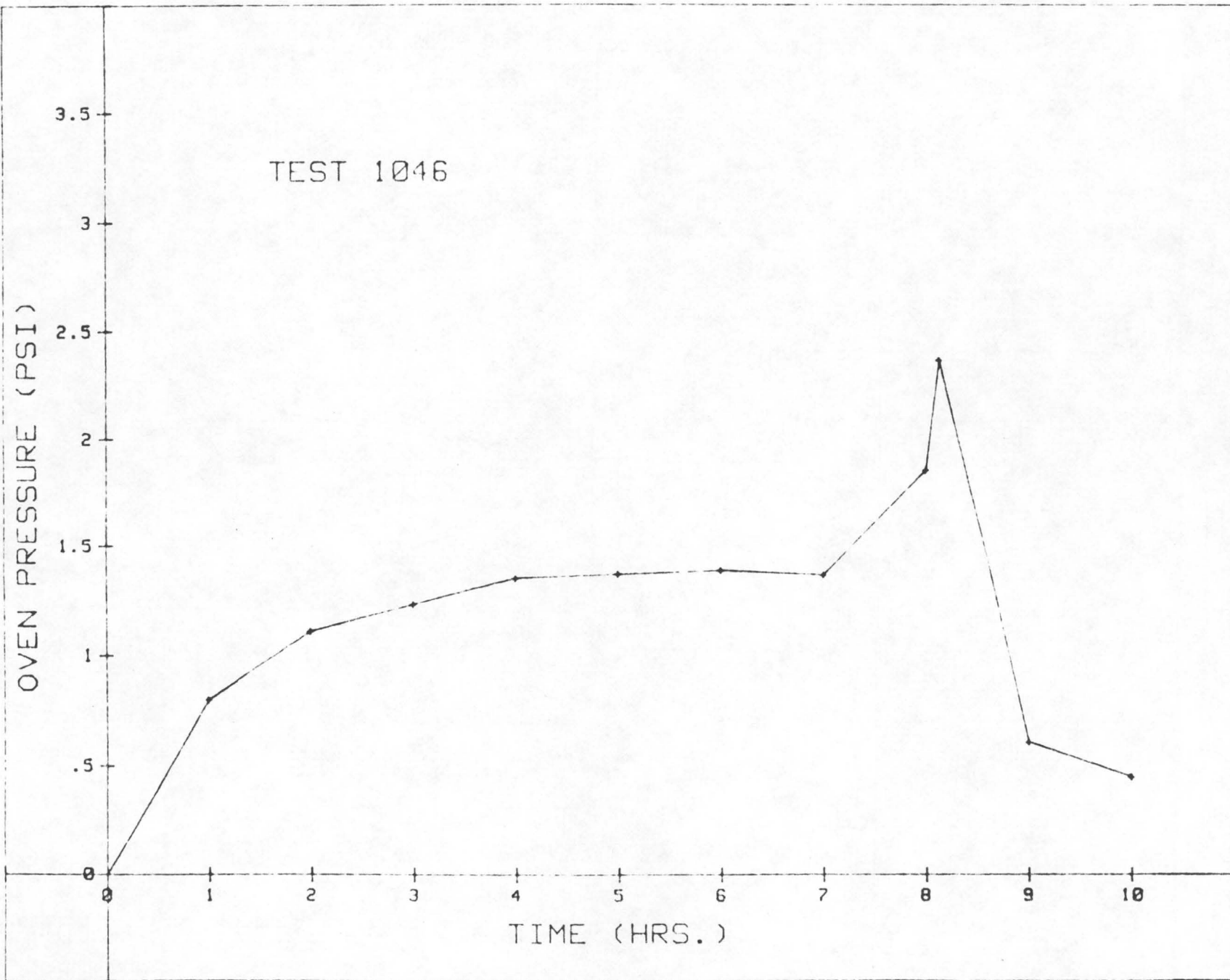


Fig. 7 - Relationship between wall pressure and hours after charging in CANMET MW coke oven (DOFASCO Mix No. 131, Test No. 1046)

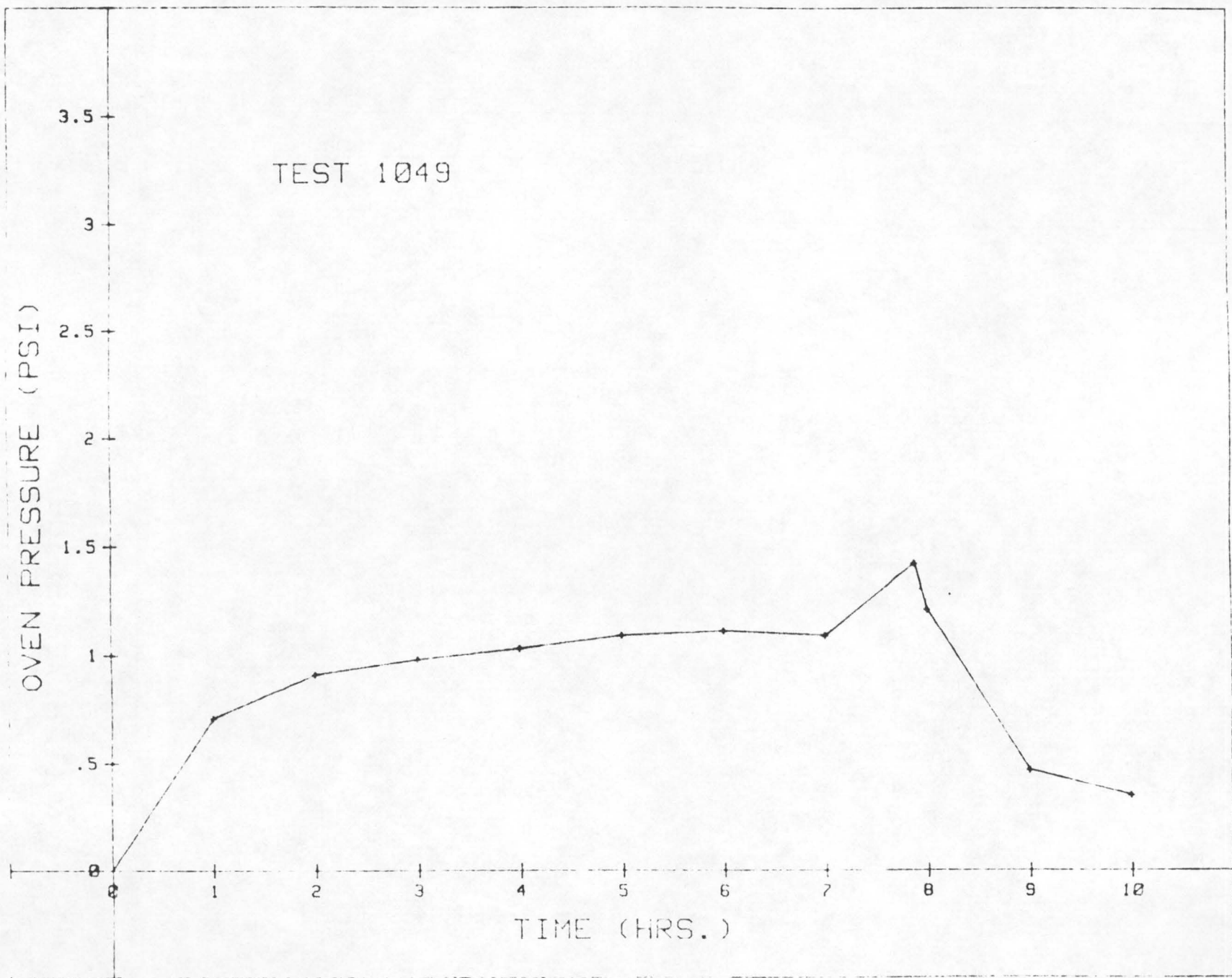


Fig. 8 - Relationship between wall pressure and hours after charging in CANMET MW coke oven (DOFASCO Mix No. 131, Test No. 1049)

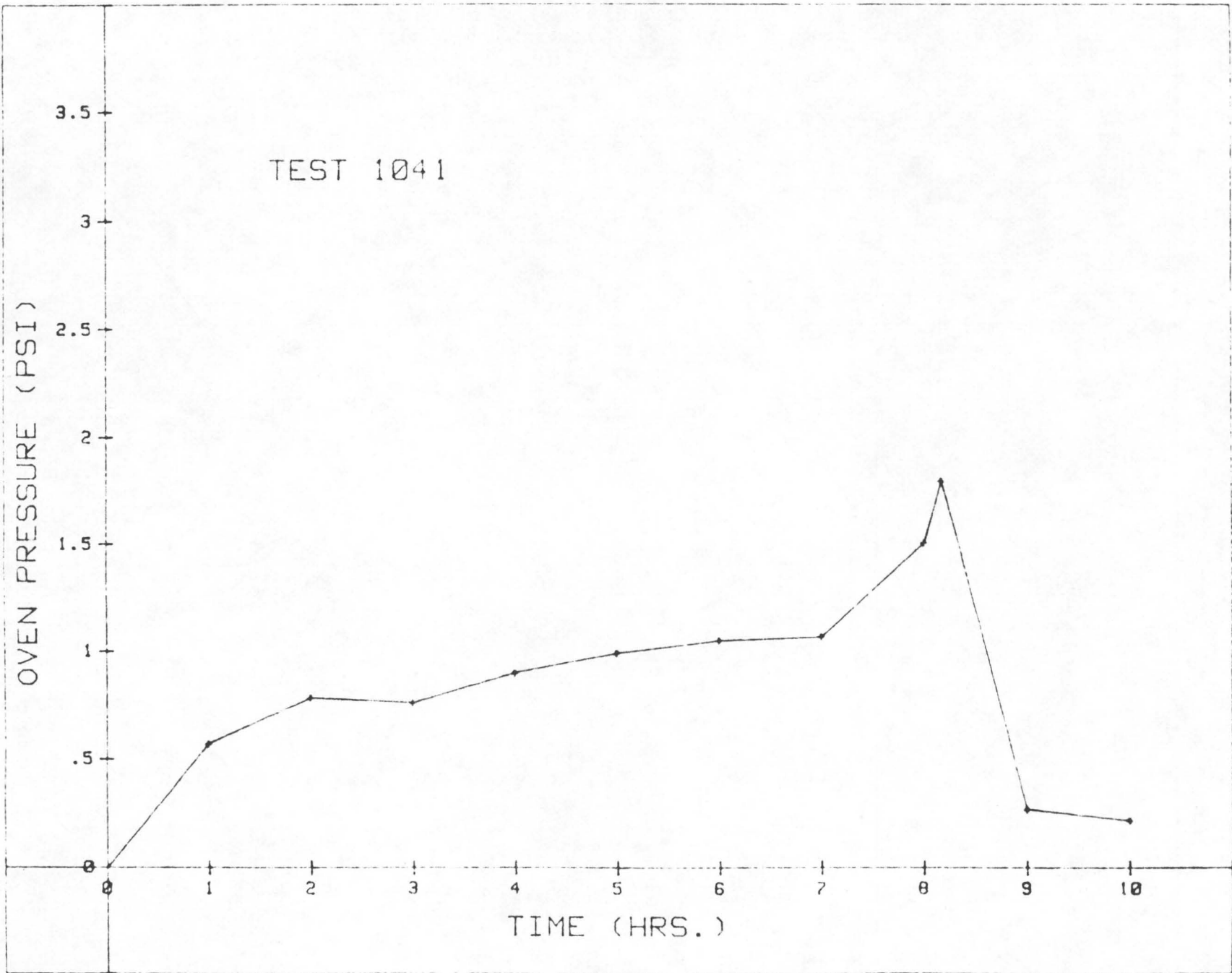


Fig. 9 - Relationship between wall pressure and hours after charging in CANMET MW coke oven (DOFASCO Mix No. 132, Test No. 1041)

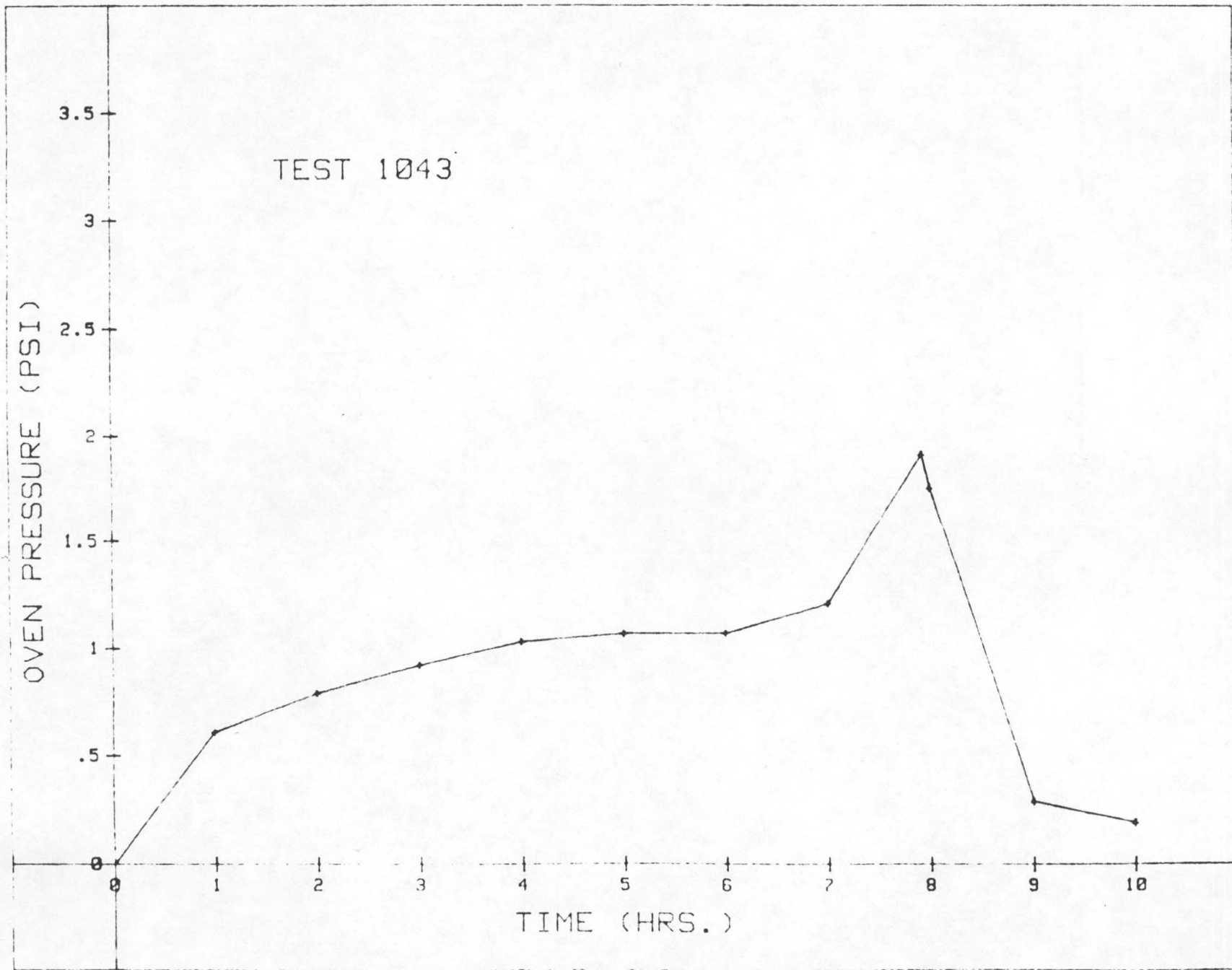


Fig. 10 - Relationship between wall pressure and hours after charging in CANMET MW coke oven (DOFASCO Mix No. 132, Test No. 1043)

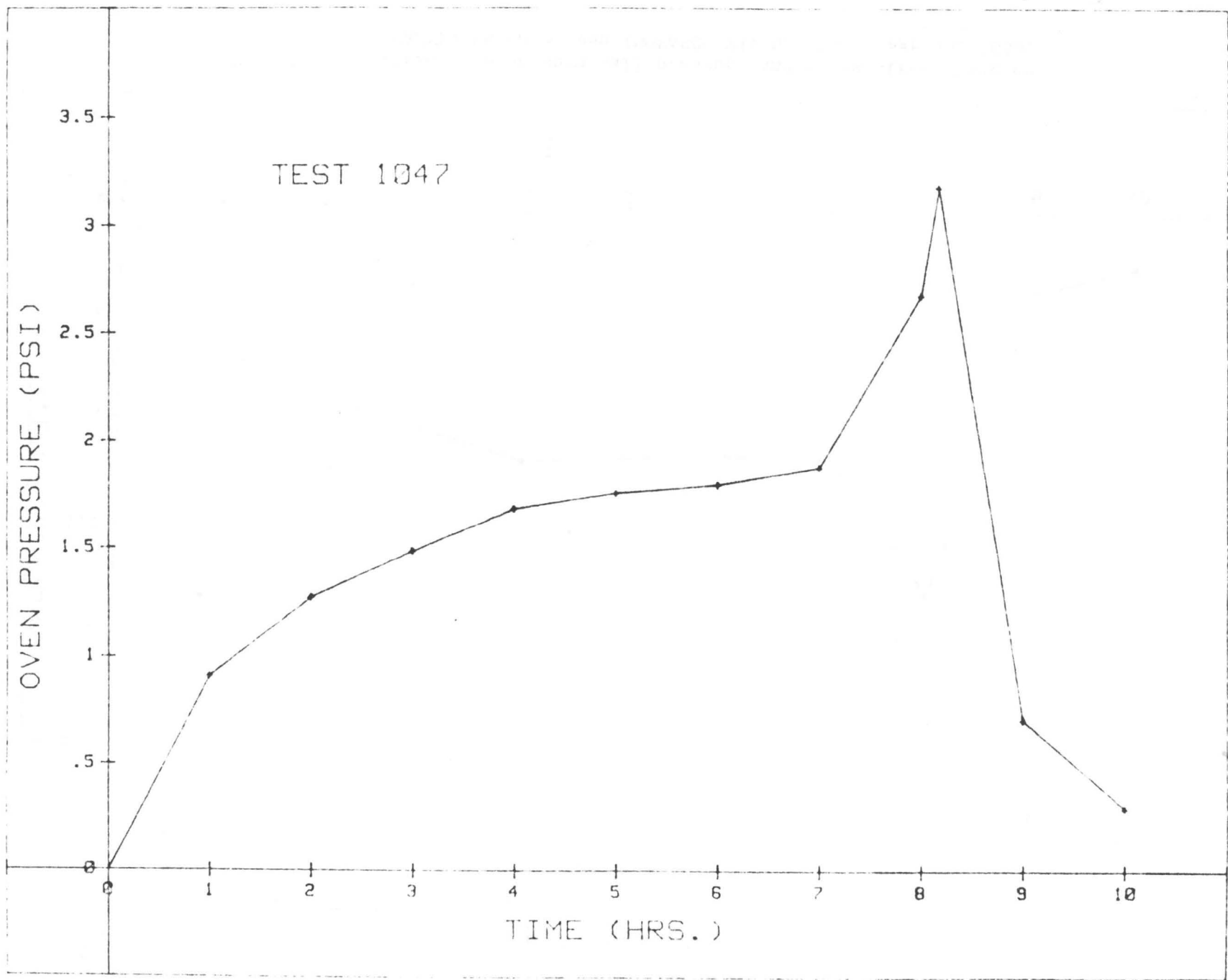


Fig. 11 - Relationship between wall pressure and hours after charging in CANMET MW coke oven (DOFASCO Mix No. 133, Test No. 1047)

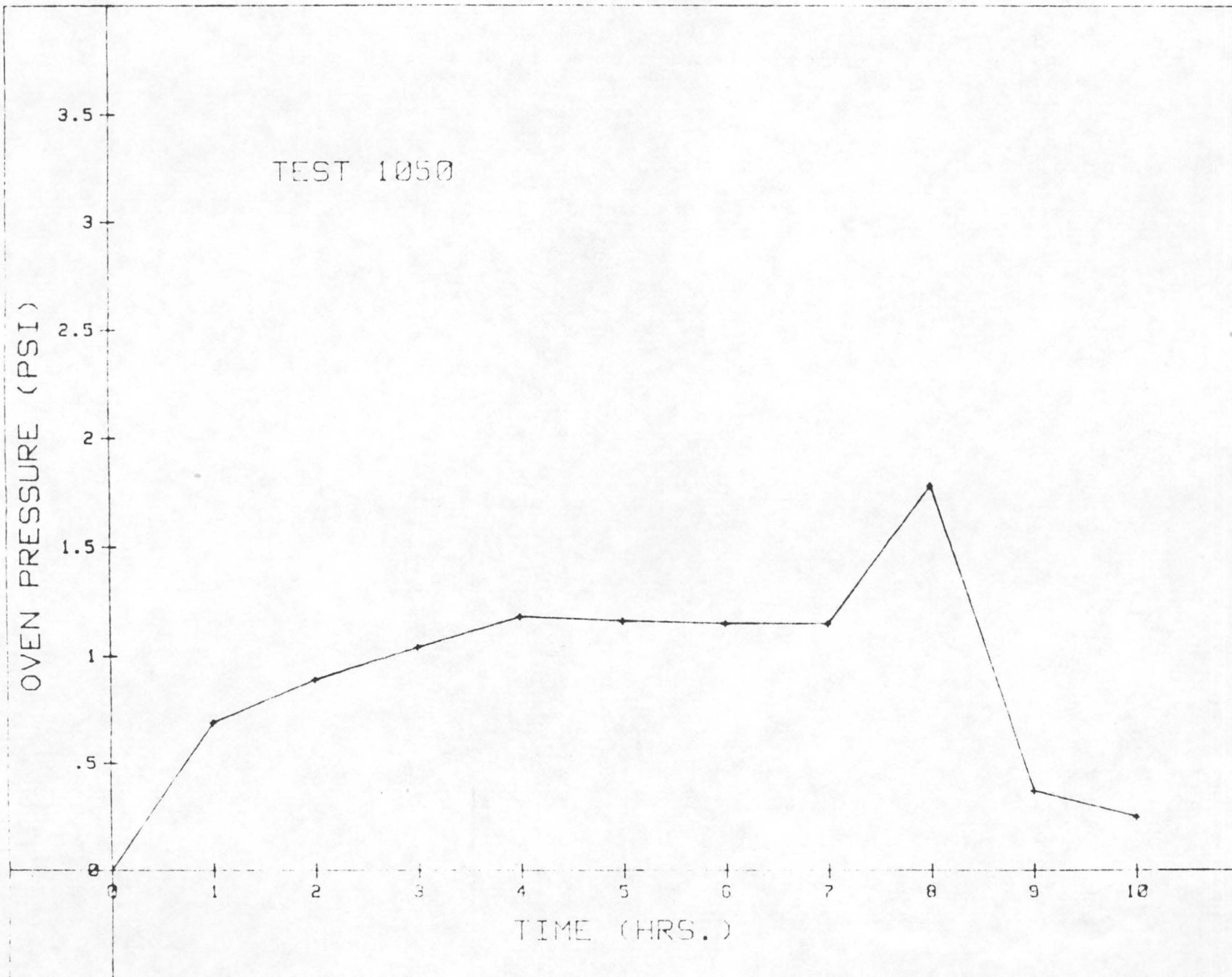


Fig. 12 - Relationship between wall pressure and hours after charging in CANMET MW coke oven (DOFASCO Mix No. 133, Test No. 1050)

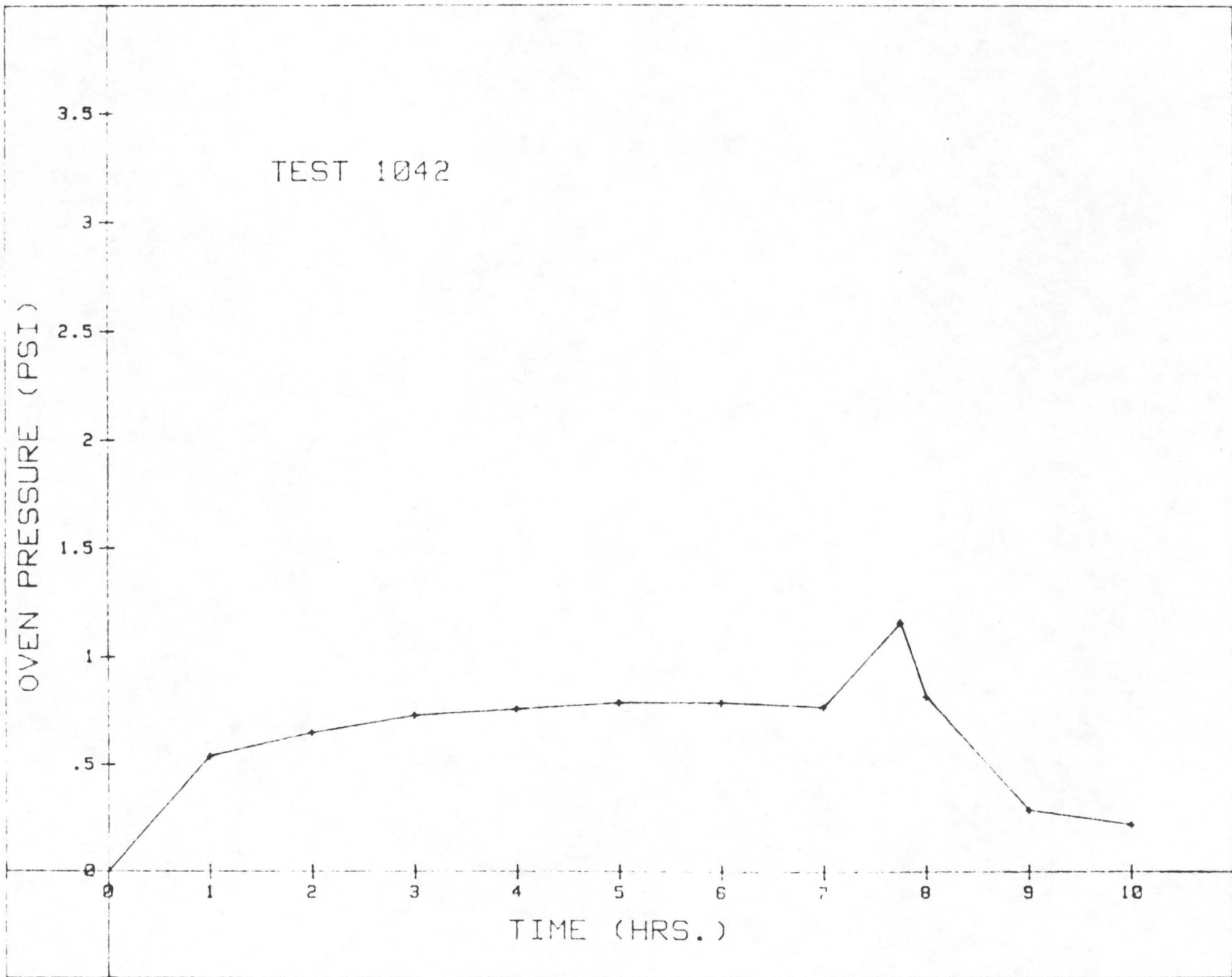


Fig. 13 - Relationship between wall pressure and hours after charging in CANMET MW coke oven (DOFASCO Mix No. 134, Test No. 1042)

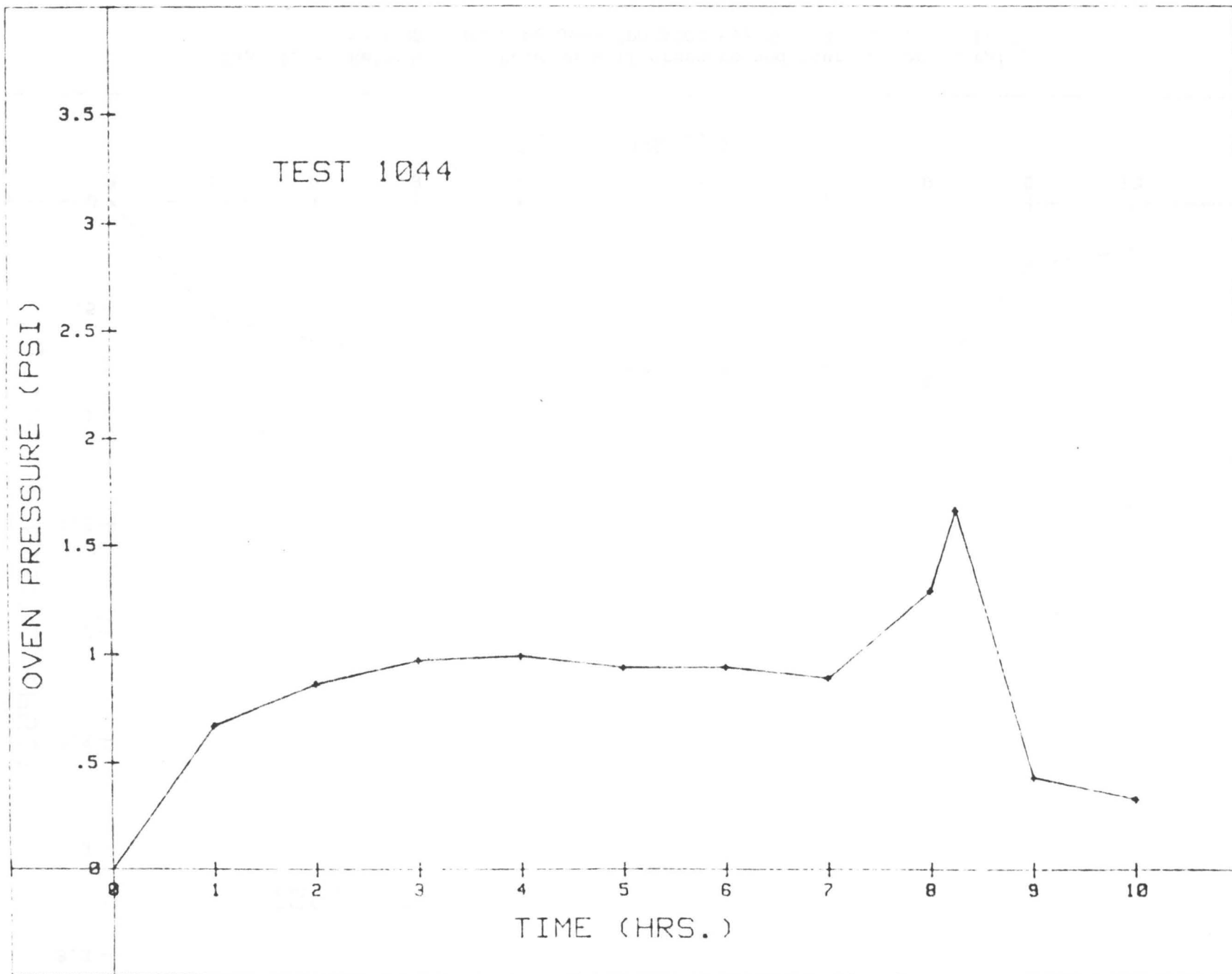


Fig. 14 - Relationship between wall pressure and hours after charging in CANMET MW coke oven (DOFASCO Mix No. 134, Test No. 1044)

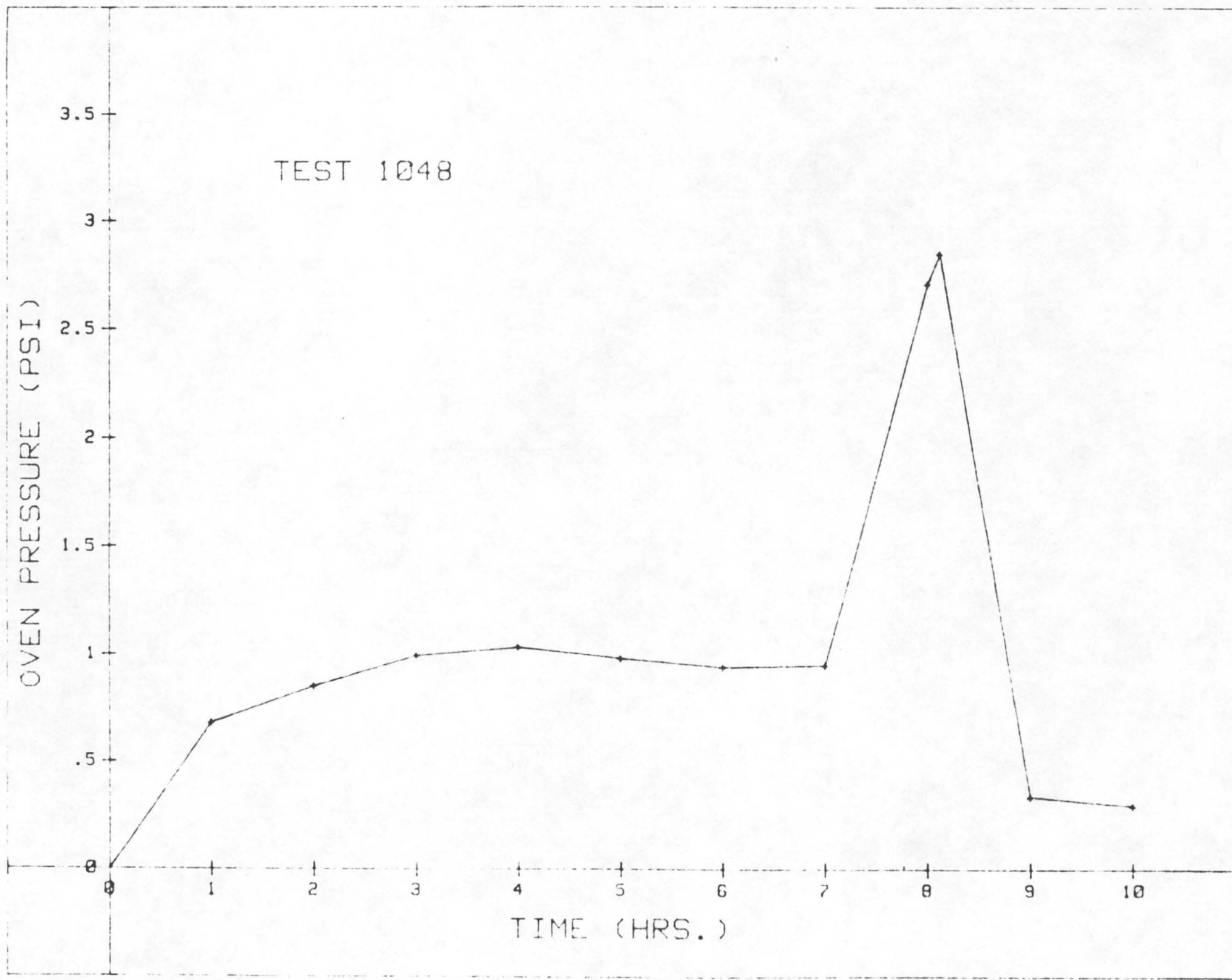


Fig. 15 - Relationship between wall pressure and hours after charging in CANMET MW coke oven (DOFASCO Mix No. 135, Test No. 1048)

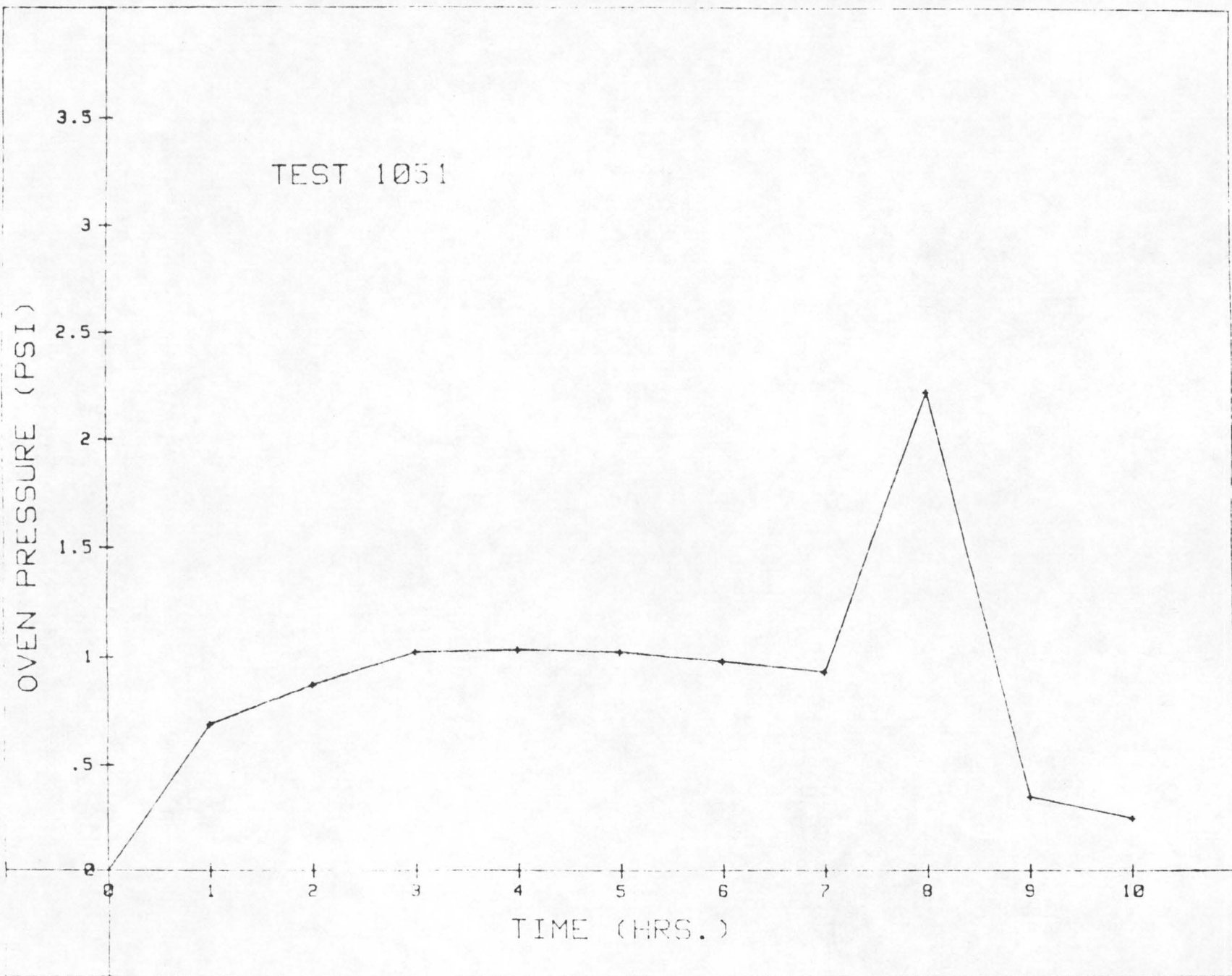


Fig. 16 - Relationship between wall pressure and hours after charging in CANMET MW coke oven (DOFASCO Mix No. 135, Test No. 1051)

BIBLIOGRAPHY

1. Eddinger, R. Tracy and Mitchell, John "Pilot-scale ovens - development and operation"; Proc of Blast Furnace, Coke Oven and Raw Materials Committee; AIME 15:148-163; 1956.
2. ASTM Designation: D388-66; "Classification of coals by rank".
3. ASTM Designation: D720-67; "Free swelling index of coal".
4. ASTM Designation: D2639-74; "Plastic properties of coal by the constant-torque Gieseler plastometer".
5. Burrough, E.J. "Specific volatile index"; Fuels Division Memorandum 97/58-CG; Fuels and Mining Practice Division, Mines Branch, Dept of M. and T.S.; Ottawa, Canada; 1958.
6. ASTM Designation: D409-71; "Grindability of coal by the Hardgrove - machine method".
7. ASTM "Proposed method of test for measuring the coking pressures of coals by a movable-wall slot oven"; (presently under consideration for adoption as a standard method of test by Sub-Committee XV of ASTM Committee D-5).
8. ASTM Designation: D291-60; "Cubic foot weight of crushed bituminous coal"; Procedure A - Cone Procedure for Uncompacted Cubic Foot Weight.
9. ASTM Designation: D293-69; "Sieve analysis of coke".
10. ASTM Designation: D3402-76; "Tumbler test for coke".
11. "Japanese drum test for coke"; Designated as J.I.S. (Japanese Industrial Standard) K2151-1972; pp 12-16.
12. Burrough, E.J., Strong, R.A. and Swartzman, E. "Report of investigation on the method now in use at the Fuels Research Laboratories for determination of the apparent specific gravity of coke"; R.I. C.S. 35; Division of Fuel Testing; Department of Mines; August 24, 1934.
13. ASTM Designation: D2014-71; "Expansion or contraction of coal by the sole-heated oven".
14. German Industrial Specification No. DIN 51739/March 1951.

15. ASTM Designation: D2797-72; "Preparing coal samples for microscopical analysis by reflected light".
16. ASTM Designation: D-2798-72; "Microscopical determination of the reflectance of the organic components in a polished specimen of coal".
17. ASTM Designation: D-2799-72; "Microscopical determination of volume percent of physical components of coal".
18. Schapiro, N., and Gray, R.J. "Petrographic classification applicable to coals of all ranks"; Proc Illinois Min Inst 68:83-97; 1960.
19. Hoffman, H. and Hoehne, K.; Brenstoff Chemie 35:202:236:269:298; 1954.

