Troxler Electronic Laboratories, Inc. - Troxler International, Ltd.
3008 Cornwallis Road, P.O. Box 12057, Research Triangle Park, NC 27709 - USA
Telephone: 1.919.549.8661 Telefax: 1.919.549.0761 Web: troxlerlabs.com

APPLICATION BRIEF

Model 4730/4731 NTO™
New Technology Oven

June 2000

Introduction

The quality of asphalt concrete pavement is typically characterized by two very important factors – the asphalt binder content and the gradation of the aggregates. For many years, chemical solvents were used to separate the binder from the aggregate to determine the asphalt content and gradation. The danger of using these toxic solvents coupled with tighter disposal regulations have made chemical extraction an expensive test method. In the early 1990s the National Center for Asphalt Technology (NCAT) developed a method of separating the binder from the aggregates by igniting a sample of the mixture which caused the binder to burn away leaving the aggregates. This ignition method rapidly became the preferred means of measuring the amount of asphalt binder in a mixture.

This paper describes the second generation of ignition devices. The Troxler NTO maintains the basic principles of the ignition method and offers many advanced features not presently available to the asphalt production industry.

Theory of Operation

Troxler's Model 4730/4731 NTO is an ignition oven that uses infrared as the source of heating. This allows the mixture to burn quicker, and the chamber temperature to be greatly reduced compared to the first generation of ignition furnaces. Using infrared heaters also decreases the electrical power requirements, so the NTO may be powered by either a 208/240 V ac supply or a 120 V ac, 15 Amp supply. In the ignition process, the mixture is heated until combustion of the binder is achieved. The NTO provides an advanced burn process that removes the binder more efficiently. The loss in sample weight is directly related to the binder content. After the burn is complete, the aggregates are removed from the oven and allowed to cool for subsequent gradation analysis.

Heat Transfer Technology

In order to burn the binder in an ignition oven, heat must be transferred from a source to the asphalt material. In nature, heat transfer may occur by conduction, convection, or electromagnetic energy waves.

Conduction requires the heat source and object to be in direct contact. An example of this is a hot water heater where the heater element is submerged in the water. The heat generated by the current in the element is directly transferred to the surrounding water.

With *convection* transfer the heat is first transferred to the boundary of air close to and in contact with the heater element. The object is then heated with the air currents. All ignition furnaces currently in use rely on convection heat transfer method. This requires that the chamber air surrounding the asphalt sample be heated sufficiently to transfer the heat to the asphalt.

The third means of heat transfer is by *electromagnetic energy waves*. An example of electromagnetic heating is the Sun warming the surface of the Earth. The space between the Sun and the Earth is transparent to the energy waves from the Sun. The thermal energy from the Sun is absorbed in the Earth's surface and the air surrounding the Earth is warmed by conduction; yet, the atmosphere at 10,000 feet has a temperature well below zero. In the case of the Troxler Ignition Oven, the energy waves come from the infrared portion of the electromagnetic spectrum. Infrared transfers heat energy directly to the sample by exciting the molecules in the asphalt mixture without heating the surrounding air in the chamber. As a secondary effect, the chamber air is heated by conduction/convection transfer from the asphalt mixture directly excited with the infrared thermal energy.

Operating Procedure

Operating the NTO is very simple. Prior to beginning a burn process, the operator need only select the burn profile (*see Features*) and the appropriate aggregate correction factor. To begin the test, the weight of the empty sample tray assembly is determined and the mixture sample is placed evenly in the sample trays. Weigh the tray assembly with the mixture then subtract the weight of the empty sample tray assembly from the weight of the total mixture sample and the tray assembly to determine the sample weight. The sample weight is entered by the keypad, the tray assembly and mixture is placed in the chamber, the door is closed and the START key is pressed. This will initiate the burn process. The door will be locked to prevent accidental opening during the burn, and the printer will begin to print the start of the burn ticket. The NTO is programmed to automatically turn off when the weight loss does not exceed .010 percent in three consecutive minutes. At the completion of the burn, a red light and a buzzer will turn on to alert the operator to remove the sample from the oven.

Features

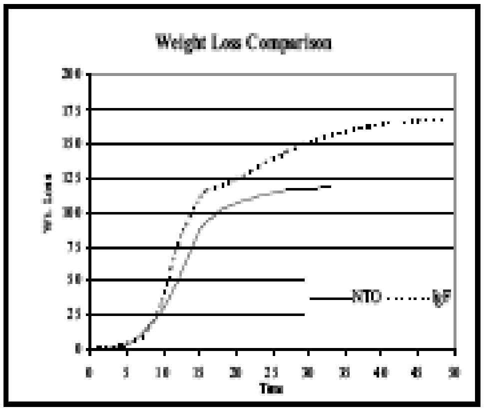
- PATENTED INFRARED TECHNOLOGY that produces the quickest and cleanest burns.

- PORTABLE, weighs only 63.5 kg (140 lbs)

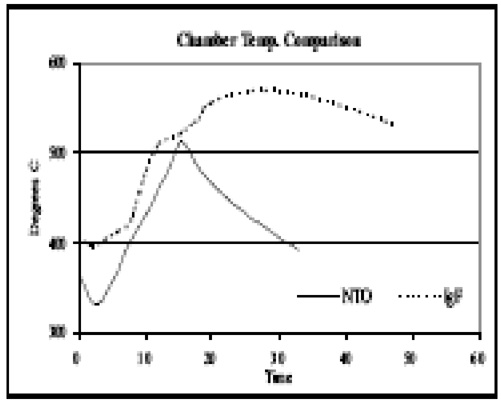
- SAMPLE SIZE UP TO 5000 GRAMS. Typically, the amount of mixture is determined by the top size aggregate with the larger stone mixtures requiring more sample mass.

- NO TEMPERATURE CORRECTION FACTOR NEEDED. Convection type furnaces in use today require the entry of a temperature correction factor to account for the air flow around the weighing device. The NTO uses a proprietary process design that eliminates this potential source of error. This is one less step that the operator has to remember to perform.

- IMPROVED BURN CHARACTERISTICS



This chart compares a first generation ignition furnace - IgF and the NTO. This shows the results of actual burns conducted at an asphalt production plant. The same mixture and approximately same sample mass were tested in each device. This chart illustrates how much faster the burn is completed in the NTO compared to the same burn in a leading ignition furnace.



This chart compares the first generation ignition furnace – IgF and the NTO showing the lower operating temperature in the NTO. Note that the first generation ignition furnace reaches a much higher temperature and takes a longer time to begin cooling; whereas, the NTO starts cooling the chamber immediately after reaching a lower maximum temperature.

- CLEANER BURNS WITHOUT FILTERS OR AN AFTERBURNER (see Emissions)

- ELECTRICAL

Power Supply	Model 4730	Model 4731
	120 V ac	208/240 V ac
	50/60 Hz	50/60 Hz
Current	12 amps	12/13 amps

- SELECTABLE BURN PROFILES – with the first generation ignition furnace, the aggregate correction factor for soft aggregates could be improved by lowering the chamber temperature. The NTO has an unlimited ability to control the burn sequence during every minute of a burn cycle. By testing a broad cross section of asphalt mixtures, Troxler has developed a series of burn profiles which allows the operator to fine tune each burn based on the aggregate type. Three burn profiles are selectable by the operator:

DEFAULT –	The optimum profile for granite and other hard aggregates.
OPTION 1 –	The profile of choice for very soft aggregates such as dolomites or limerock. Any mixture with a large aggregate correction (>1.0%) will probably need option 1.
OPTION 2 –	Covers some very rich Superpave type mixtures with special modifiers. In addition, this option may work well with base (large stone) type mixtures.

Emissions

One of the many benefits of the NTO is reduced emissions released into the environment compared to the ignition furnaces in use today. These low emissions are achieved without the necessity of an afterburner or filters. The NTO was developed with the intent of reducing emissions. The proprietary design enables the mixture burns to be more efficient and complete.

An evaluation of emissions was conducted over a four month period. A Lancom Series II emission test apparatus manufactured by Land Combustion was used to measure the emission of the contaminants listed in the table on the next page. Several different types of asphalt mixtures were burned in both new NTO ovens and a leading ignition furnace manufactured by a competitor. Multiple units were tested to provide a reliable database. Four NTO ovens were used in this study. Two units had a 120-volt power supply and two units had a 240-volt power supply. The competitor unit must operate on a 240-volt power supply. It should also be noted that the emissions from the competitor unit will change depending on when the filters were last cleaned.

The table below shows the results of the evaluation. The results are given as peak output in parts per million, except for the hydrocarbons which is shown as a %. Comparing the mean of the contaminant emissions from a Troxler NTO and the leading competitor furnace, the emissions from the NTO average 61% less for the contaminants measured.

Peak Concentrations of Contaminants

	CO (ppm)	**SO_2 (ppm)**	**H_2S (ppm)**	**CxHx (%)**
NTO A	750	240	24	-
NTO A	110	230	19	0.02
NTO B	1550	480	30	0.11
NTO C	1500	180	14	0.09
NTO C	1550	265	18	0.11
NTO D	1650	270	21	0.09
NTO D	950	295	22	-
Mean	**1293**	**280**	**21**	**0.88**
Competitor Unit	3900	630	62	0.23
	3550	550	52	0.20
	4500	770	82	0.26
	3900	610	68	0.26
	2800	400	44	0.17
Mean	**3730**	**592**	**62**	**0.22**
Troxler NTO is lower in contaminant emissions by:	65%	52%	66%	62%

Results

MIXTURE TESTING IN THE NTO BEFORE PRODUCTION

An important component of the pre-release testing of this new technology was burning many different types of asphalt mixtures in the NTO. Plant produced mixes were gathered from Delaware, North Carolina, Alabama, Florida, Illinois, Texas, Colorado, and California. These mixes were both Marshall and Superpave™ designs and had been tested in a convection type ignition furnace at the plants.

The table below shows the average results from burning these mixtures in an NTO and performance against convection oven burns in the field. For the majority of these samples, the %Loss is very comparable to field burn results. Also, the burn time using the NTO is much quicker than the field burn time.

Mix ID	Design % AC	Field % Loss	NTO % Loss	Field Burn Time	NTO Burn Time
12.5 mm Superpave	4.93%	5.29%	5.39%	48	26
12.5 mm Superpave	5.80%	5.92%	6.03%	—	31
19 mm Superpave	5.06%	6.16%	5.81%	87	59
19 mm Superpave	4.67%	5.15%	5.18%	56	45
25 mm Superpave	5.26%	5.35%	5.36%	55	36
Surface Mix	5.90%	6.30%	6.28%	34	32
Surface Mix	6.61%	6.76%	6.62%	46	47
Surface Mix	5.16%	5.68%	6.26%	54	37
Binder Mix	5.14%	5.29%	5.16%	45	37
Binder Mix	4.64%	5.03%	4.84%	34	27
Binder Mix	4.16%	4.37%	3.99%	42	34
Base Mix	4.20%	4.40%	4.30%	52	46

FIELD TESTING AT THE ASPHALT PRODUCTION PLANT

Several of the first NTOs were placed at various locations across the United States for field testing. One of these units was tested over a thirty day period and the results are shown in TABLES 1 & 2. Samples were gathered from the actual plant production. Each day, a split sample of the same mixture was tested in the NTO and a first generation ignition furnace. Results in TABLE 1 includes the sample weight, burn time and %Loss for both devices along with the Job Mix Formula (JMF) or expected %AC. The NTO was not tested with known laboratory produced mixture to identify an aggregate correction factor; therefore, only the %Loss could be compare to the first generation ignition furnace. A review of the data shows the average difference when comparing the %Loss from each device to the expected %AC was much better for the NTO. This would indicate the aggregate correction factor would be smaller for the NTO. TABLE 2 provides data on the gradation of the aggregates after each burn. In the cases where the %Loss was greatly different between the two devices, the gradation would typically be coarser for one sample than the other. These results, both the comparison of the asphalt content determination and the gradation comparison, illustrate the efficiencies and improvements that make the NTO far superior to any ignition method device presently in the asphalt production industry.

TABLE 1 — Comparison of % Loss, NTO and 1st Generation Ignition Furnace

				NTO				1st Generation Ignition Furnace				
Date	Sample #	Top Size Agg	JMF % AC	Sample Wt	Burn Time	Corr % AC	Difference to JMF	Sample Wt	Burn Time	Corr % AC	Difference to JMF	Difference NTO to 1st Gen
5/9/00	59RI1	12.5		1965.0	36	4.87		1965.0	34	5.10		0.23
5/11/00	511RI1	12.5	5.6	1925.5	29	5.69	-0.09	1666.0	31	5.68	-0.08	-0.01
5/12/00	512RI1	12.5	5.6	2291.9	40	5.25	0.35	2134.0	40	5.60	0.00	0.35
5/15/00	515RI1	12.5	5.6	1993.1	33	5.47	0.13	2665.0	48	5.76	-0.16	0.29
5/17/00	517RDB	19	4.4	2200.0	39	4.44	-0.04	2260.0	38	4.62	-0.22	0.18
5/18/00	518RI2	12.5	6.1	2239.4	40	6.02	0.08	2397.0	48	6.02	0.08	0.00
5/23/00	523RI2	12.5	6.1	2140.7	44	6.08	0.02	2008.0	43	6.07	0.03	-0.01
5/24/00	524RI2	9.5	6.1	2000.1	37	6.23	-0.13	2234.0	51	6.38	-0.28	0.15
5/11/00	511RI12	12.5	5.6	1970.8	33	5.50	0.10	1958.0	33	5.49	0.11	-0.01
5/10/00	510RI1	9.5	5.6	1815.7	30	5.80	-0.20	1934.0	36	5.67	-0.07	-0.13
5/9/00	59RI1	12.5	5.6	1687.0	31	5.28	0.32	2206.0	37	5.15	0.45	-0.13
5/6/00	56RDB	19	4.4	1962.1	30	4.51	-0.11	2556.0	39	4.49	-0.09	-0.02
5/8/00	58RI1	12.5	5.6	1658.8	32	5.48	0.12	1223.0	26	5.65	-0.05	0.17
5/4/00	54RI1	12.5	5.6	1532.5	36	5.23	0.37	2186.0	38	5.55	0.05	0.32
5/3/00	53RI1	12.5	5.6	1711.4	29	5.33	0.27	1875.0	35	5.59	0.01	0.26
5/3/00	53RHB	19	4.3	2525.2	40	4.19	0.11	2322.0	37	4.37	-0.07	0.18
5/1/00	51RI1	12.5	5.6	1906.9	33	5.69	-0.09	1801.0	32	5.73	-0.13	0.04
5/1/00	51RI12	12.5	5.6	1731.0	29	5.59	0.01	1951.0	36	5.64	-0.04	0.05
4/24/00	424RI1	12.5	5.6	2091.4	34	5.40	0.20	2047.0	40	5.63	-0.03	0.23
4/17/00	417RI1	12.5	5.6	2275.2	36	5.33	0.27	1944.0	37	5.35	0.25	0.02
4/24/00	424RI12	12.5	5.5	1828.5	34	5.68	-0.18	2195.0	43	5.51	-0.01	-0.17
5/25/00	525RAP			2461.3	39	3.08		2461.0	40	3.27		0.19
5/29/00	529RI1	12.5	6.2	1968.1	35	6.26	-0.06	2005.0	38	6.21	-0.01	-0.05
5/31/00	531RI1	12.5	5.6	1629.8	31	5.57	0.03	1509.0	31	5.63	-0.03	0.06
6/2/00	62RDB	25	4.3	1792.5	29	4.31	-0.01	2356.0	39	4.28	0.02	-0.03
6/13/00	613RI2	12.5	6.1	1547.8	33	6.01	0.09	1419.0	28	6.07	0.03	0.06
6/16/00	616RHB	25	4.9	1643.1	30	5.03	-0.13	1612.0	33	4.71	0.19	-0.32
6/27/00	627RI2	12.5	6.3	1515.6	33	6.33	-0.03	1818.0	39	6.34	-0.04	0.01
6/28/00	628RI2	12.5	6.2	1394.0	33	6.06	0.14	1595.0	34	6.24	-0.04	0.18
6/30/00	630RHB	19	4.4	1862.8	36	4.49	-0.09	2535.0	42	4.40	0.00	-0.09
7/7/00	77RDB	25	4.5	1733.3	34	4.55	-0.05	1856.0	35	4.84	-0.34	0.29
7/10/00	710RI2	12.5	6.1	1985.1	40	6.13	-0.03	1513.0	32	6.28	-0.18	0.15
7/12/00	712RI2	12.5	5.9	2086.0	41	5.94	-0.04	2018.0	40	5.92	-0.02	-0.02
7/15/00	715RDS	12.5	5.5	2266.1	43	5.39	0.11	2335.0	42	5.46	0.04	0.07
7/18/00	718RI2	12.5	6.4	1853.4	36	6.40	0.00	1766.0	38	6.37	0.03	-0.03
7/19/00	719RI1	12.5	5.6	1672.0	33	5.49	0.11	1897.0	37	5.60	0.00	0.11
8/8/00	88RI2	12.5	5.9	1277.3	28	5.98	-0.08	1779.0	35	5.92	-0.02	-0.06
				Average Difference			0.04				-0.02	0.07
				Median Difference			0.01				-0.02	0.05

TABLE 2 — Comparison of Gradation, NTO to 1st Generation Ignition Furnace

Sample #	**417RI1**		**424RI1**		**424RI12**		**51RI1**		**51RI12**		**JMF Gradation**
Sieve, mm	**Furnace**	**NTO**	**Furnace**	**NTO**	**Furnace**	**NTO**	**Furnace**	**NTO**	**Furnace**	**NTO**	
37.5											
25											
19	100	100	100	100	100	100	100	100	100	100	100
12.5	99	99	99	100	99	99	99	99	99	99	99
9.5	94	93	93	93	93	93	94	94	93	94	94
4.75	68.9	70	66	63	68	68	66	66	68	67	67
2.36	47.9	48	48	45	49	49	47	46	49	48	49
1.18	33	34	35	33	36	35	32	33	35	35	35
0.425	18	18	22	21	22	21	20	21	22	22	21
0.180	10	10	14	13	13	12	12	12	13	13	14
0.075	3.6	3.8	4.8	5.9	6.0	5.5	5.2	5.6	5.8	6.2	5.5

Sample #	**53RI1**		**54RI1**		**58RI1**		**59RI1**		**510RI1**		**JMF Gradation**
Sieve, mm	**Furnace**	**NTO**	**Furnace**	**NTO**	**Furnace**	**NTO**	**Furnace**	**NTO**	**Furnace**	**NTO**	
37.5											
25											
19	100	100	100	100	100	100	100	100	100	100	100
12.5	99	98	99	100	99	99	99	99	100	100	99
9.5	93	92	91	92	94	94	92	94	94	97	94
4.75	69	67	62	62	67	66	64	66	70	74	67
2.36	49	48	43	43	49	47	44	47	51	54	49
1.18	36	35	31	31	35	35	33	33	37	39	35
0.425	22	21	19	19	21	23	21	21	23	24	21
0.180	13	12	11	12	14	14	11	12	13	14	14
0.075	4.7	4.5	5.5	5.5	5.5	6.1	4.5	5.0	5.9	6.5	5.5

Sample #	**511RI1**		**511RI12**		**512RI1**		**515RI1**		**JMF Gradation**
Sieve, mm	**Furnace**	**NTO**	**Furnace**	**NTO**	**Furnace**	**NTO**	**Furnace**	**NTO**	
37.5									
25									
19	100	100	100	100	100	100	100	100	100
12.5	99	99	99	99	99	99	99	99	99
9.5	95	95	94	93	93	90	93	92	94
4.75	71	70	69	70	66	63	66	63	67
2.36	50	50	50	51	46	45	47	46	49
1.18	36	36	36	37	34	33	35	33	35
0.425	22	22	23	23	21	21	23	21	21
0.180	12	12	13	13	13	13	13	12.2	14
0.075	5.1	5.3	5.9	6.0	6.0	6.1	5.1	5.5	5.5

Sample #	**518RI2**		**523RI2**		**524RI2**		**JMF Gradation**
Sieve, mm	**Furnace**	**NTO**	**Furnace**	**NTO**	**Furnace**	**NTO**	
37.5							
25							
19	100	100	100	100	100	100	100
12.5	99	99	99	97	100	100	100
9.5	93	96	95	95	95	96	95
4.75	76	77	80	80	79	78	76
2.36	59	60	61	61	59	59	60
1.18			44	44	43	42	44
0.425	27	28	27	27	26	26	25
0.180	15	17	16	16	15	15	16
0.075	6.9	8.1	6.9	6.8	6.3	6.6	6.3

TABLE 2 — Continued

Sample #	56RDB		517RDB		JMF Gradation
Sieve, mm	**Furnace**	**NTO**	**Furnace**	**NTO**	
37.5					
25	100	100	100	100	100
19	96	97	97	99	98
12.5	77	78	80	79	75
9.5					
4.75					
2.36	37	38	40	40	40
1.18	27	27	29	29	29
0.425	17	17	18	19	16
0.180					
0.075	4.2	4.8	4.8	5.3	3.6

Sample #	53RHB		55RHB		JMF Gradation
Sieve, mm	**Furnace**	**NTO**	**Furnace**	**NTO**	
37.5					
25					
19	73	77	76	73	73
12.5					
9.5					
4.75	36	33	35	36	36
2.36	31	28	28	31	31
1.18	23	20	18	23	23
0.425	14	13	12	14	14
0.180					
0.075	4.4	3.8	4.8	4.4	4.4