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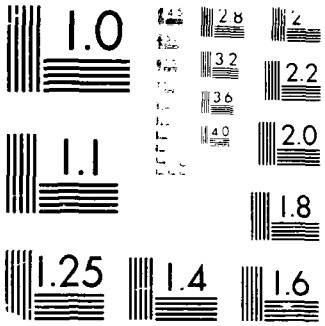


MICROCOPY RESOLUTION TEST CHART

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# The Effect of Weathering on Octane Quality for Winter-Grade and Summer-Grade Gasoline


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December 1987

Final Report

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16. Abstract

Weathering tests were conducted to examine the effects on fuel volatility and octane characteristics. The commercially available gasolines utilized in the study represented a wide geographic distribution for both winter and summer fuels. Aging was accomplished by heating the fuel samples to 110 degrees F and maintaining that temperature for 48 hours. Time histories of Reid Vapor Pressure (RVP) were conducted. Fuel octane evaluations, both MON and RON, were done. Component characterization by gas chromatography were made to identify components lost during the aging process.

The time histories of vapor pressure changes depended to a limited measure on the initial fuel vapor pressure as well as to differences in composition. Butanes and isopentanes were the primary constituents lost due to the weathering. For the most part octane changes due to fuel weathering were minimal.

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## EXECUTIVE SUMMARY

This report describes studies conducted at the National Institute of Petroleum and Energy Research (NIPER) for the Federal Aviation Administration (FAA) under a cost sharing agreement with the U.S. Department of Energy. In these studies, the effect of aging automobile gasoline on its volatility and its octane rating was measured.

The samples tested in this program represented a wide geographic distribution for both winter and summer blends of automobile gasoline. Aging was accomplished by heating the samples to 110° F in vented containers and keeping the fuel sample at that temperature for 48 hours. The change in the volatility of the fuel was measured using the Reid Vapor Pressure (or an equivalent test and correcting it to the Reid Vapor Pressure). The research and motor octane numbers were measured before and after aging. The distillation curve of each fuel was determined for both the initial and aged samples. The constituents of each fuel were identified for both the initial and aged samples using gas chromatography and the principle constituents lost during aging were identified.

The changes in the distillation curve and the Reid Vapor Pressure were greater for the winter-grade fuels than the summer-grade fuels. This was expected since the winter-grade fuels contain a larger percentage of low molecular weight constituents (e.g., butane and isopentane) and these are the principle components lost during the aging process.

The changes in octane as a consequence of aging were, for the most part, negligible. The principle exception was for the winter-grade sample of fuel from Philadelphia which contained an unusually high percentage of butane. The change in octane rating was similar for both the winter grade and the summer grade fuels.

# WEATHERING EFFECTS ON FUEL QUALITY

## INTRODUCTION

The mandated reduction in fuel lead level and an increasing demand for high octane quality fuels necessary for maximum performance of vehicles require refineries to consider all possible means to produce acceptable quality fuels at competitive costs.

In the light aircraft industry, concerns exist that the substitution of motor gasoline for aviation gasoline might result in engine failure during maximum power demands. Weathered fuels which have lost higher volatility components will have qualities that are more closely related to the remaining lower volatility components. The bulk of the remaining portion lies in the distillation range that would be produced from alternative feedstocks and these tend to be the lower octane components. Requests to the Federal Aviation Administration (FAA) for autogas certification have raised questions concerning current regulations. The fuel certification procedures require aircraft fuel tests to be conducted at 110° F. Concerns are related to the higher volatility characteristics of autogas compared to aviation gas and the possibility of inducing vapor lock at high temperatures. There is also inadequate information regarding the weathering effect of fuel storage at high temperature and resultant effects on fuel octane quality.

## EXPERIMENTAL PROGRAM

The experimental program at the National Institute for Petroleum and Energy Research (NIPER) was initiated to provide information to aid in making technical judgments on fuel, fuel specifications, and fuel conditioning requirements for a range of fuels that could be utilized in current light aircraft. This portion of the work is centered on determining the acceptability of motor fuels that have been weathered, causing loss of volatile components.

### TEST FUELS.

Commercial auto gasolines from various locations were surveyed for volatility and octane quality--in both as-received and after-weathering conditions. Antiknock quality was evaluated to assess the suitability of this variety of auto fuels for aviation applications. Experiments have been conducted with ten winter (January-February) and ten summer (July-August) fuels that were obtained from commercial suppliers representing various geographic (refining) areas in the contiguous 48 states. The fuels were tested in as-received condition with no modifications to the existing vapor pressures. Specific fuel properties will be presented in the section dealing with test results.

### TEST PROCEDURES.

Prior to testing, all fuels were stored in air tight sealed drums at 50° F and equilibrated at that temperature for a minimum of one week. The fuel weathering tests involved transferring the fuels to vented test tanks, heating

the fuel to 110° F and maintaining that fuel temperature for a 48-hour period. This time period was chosen to ensure noticeable aging effects following equilibration at 110° F. Fuel samples were taken within one hour of the time required for the fuel to equilibrate at 110° F and at 12, 24, and 48 hours afterward for determination of vapor pressures. In addition, fuel samples were taken both from the initial or fresh fuel and at the 48-hour point following temperature equilibration. These samples were analyzed for distillation characteristics (ASTM D 86), research octane number (RON) (ASTM D2699) and motor octane number (MON) (ASTM D2700). An attempt to identify specific components of the gasolines which are lost due to weathering at this temperature was conducted using gas chromatographic techniques.

Two fuel tanks representative of light aircraft were used. These were rectangular shaped with low height and large bottom surfaces. The total tank volumes were nominally 13 gallons. Each tank was vented through fill ports and this area was less than 2 percent of the tank top area. The tanks were placed on stands in a test cell having a temperature control range of 50° to 120° F ± 1°. Thermocouples were placed in the tanks approximately one inch above the bottom surface to monitor fuel temperature, and additional monitoring for temperature history was made with a chart recorder. The tank levels specified were a minimum of 90 percent full.

The test procedure consists of the following:

1. Fuels were stored at an ambient temperature 50° F and an initial (fresh fuel) sample was taken under these conditions.
2. Test fuel tanks were filled with 50° F fuel to the 12-gallon (92 percent full) level.
3. Tank vents were left open to the atmosphere.
4. The tanks were then placed in the soak area and heated to a fuel temperature of 110° F. This fuel temperature was controlled by room ambient temperature throughout the test to ± 1° F.
5. Fuel samples were taken within one hour of attaining the desired temperature. This was referred to as time = 0.
6. Additional samples were taken at 12, 24, and 48 hours following equilibration at 110° F.

As mentioned earlier, additional measurements were made with the intial and 48-hour samples. These included:

1. Distillation characteristics by ASTM D 86 technique.
2. Fuel octane evaluations--both RON and MON.
3. Component characterization by gas chromatographic analyses.

Vapor pressure measurements were made from all samples taken. The fuel samples for vapor pressure analyses were stored and equilibrated at 50° F. Vapor pressure measurements for the ten winter grade fuels were made at NIPER using the ASTM microvapor pressure (MVP) procedure D 2551-71. The MVP was measured with a model "G" vapor pressure gauge from Manufacturers Engineering and Equipment Corporation.

The micro method was developed as an alternative to the standard RVP procedure ASTM D 323 to offer an advantage in speed and size of sample required. The RVP method consisted of filling a gasoline chamber of vapor pressure apparatus with a chilled sample of gasoline. The gasoline chamber was connected to an air chamber maintained at 100° F, and the apparatus was immersed in a bath at 100° F and shaken periodically until a constant pressure was observed on a gauge attached to the apparatus. The gauge reading, suitably corrected, was reported as Reid vapor pressure.

The microvapor pressure consisted of introducing a liquid sample into an evacuated chamber fitted with means of measuring pressure in the chamber before and after sample introduction. The apparatus was immersed in a constant temperature bath of 100° F. Both the RVP and MVP procedures used vapor/liquid volume ratios of about 4:1.

When a sample of volatile hydrocarbons is saturated with air and introduced into a chamber and allowed to equilibrate, the increase in pressure is equal to the sum of the following four pressures:

1. The vapor pressure of the liquid at the temperature of the chamber.
2. The partial pressure of the dissolved air that comes out of solution.
3. The partial pressure of the dissolved water.
4. The compression effect of the liquid volume on initial air within the chamber.

The only significant pressures of these four which contribute to the total pressure are the first two, the vapor pressure of the sample and partial pressure of the dissolved air.

By nature of the systems, the evacuated chamber associated with the MVP presumes that all dissolved air will come entirely out of the solution and be measured and corrected; whereas, the Reid method (above atmospheric pressure) automatically compensates for the effect of dissolved air. Therefore, the RVP of a given sample will always be lower than the MVP of the same sample. For conversion of MVP results to RVP, the MVP may be corrected for the effect of dissolved air or empirically correlated with Reid values.

The samples were saturated with air at 50° F and pressures measured by mercury manometer at 100° F by mercury manometer. The empirical mathematical relationship of MVP and RVP was supplied with the test apparatus.

The relation:

$$\text{FRVP, psi} = 0.019\ (\text{MVP, mmHg}) - 0.66$$

allows the measured MVP to be expressed as an equivalent Reid vapor pressure (FRVP).

The summer fuel vapor pressure measurements were made using the Reid procedure. A Herzog semi-automatic Reid vapor pressure apparatus was used. The change in vapor pressure apparatus for the summer measurements was made primarily for purpose of faster turnaround. Results from the two types of vapor pressure measurements were examined at NIPER for a variety of fuels in the pressure range of interest and were found to be very comparable.

## RESULTS

### WINTER-GRADE FUELS.

Table 1 shows a tabular history of the fuel vapor pressure changes due to weathering effects at 110° F. The fuels are identified by the city of origin. These data are presented as ERVP. The vapor pressure samples were taken within the previously defined time limits. As a group, the original or unweathered pressures had (with Philadelphia as an exception) an approximate range of 12.5 to 14 psi. The Philadelphia fuel had a value of 16.1 psi. The weathered values varied from about 10 to 11 psi indicating losses in ERVP ranging from about 2.0 to 3.7 psi for the 48-hour period.

Figures 3 through 5 are the plotted vapor pressure results for fuels which were tested simultaneously. It should be noted that the differences in equilibration time (from initial sample to t = 0) are due to changes in test cell heating capabilities. An initial malfunction in the system was responsible for longer equilibration periods as seen in the Denver-Wichita plot (figure 4). These times were reduced to around 10 hours following repairs. Cell temperatures at times reached 130° F during this period, but careful modulation assured no fuel temperature excursions from the target values. A linear regression analysis was conducted on the results for the winter grade fuels. From these results there appears to be a strong relationship between the change in vapor pressure and the initial RVP; that is, the higher the initial RVP, the greater the change due to weathering. However, this relationship is also affected by fuel compositional differences. The data suggest that fuels with similar initial vapor pressures, i.e., Denver-Wichita and Rockville-San Diego, do not necessarily weather similarly. These differences would appear to be attributable to compositional differences. In general, most of the vapor pressure decreases occurred before the 12-hour weathering point.

Table 2 presents octane changes (both RON and MON) for these ten high vapor pressure winter fuels. Decreases in octane quality due to weathering appeared to be minimized and were generally less than 0.3 octane number. Most of these data were within experimental repeatability. An exception is seen with the winter Philadelphia regular unleaded fuel. A decrease of 0.7 in MON was noted and as can be seen in the compositional data, is attributed to the high initial content of butane.

Figures 6 through 15 show changes in the fuels' distillation character due to the controlled weathering conditions. The fuels all exhibited similar trends, with the major effect due to loss of volatile front-end components.

Increases in fuel initial boiling point (IBP) attributable to the 110° F weathering varied from 10° to 80° F. Ten-volume percent distilled level changes varied from a low of 12° F for the Sacramento fuel to a high of 16° F for the unleaded fuel from Wichita.

All of the fuels showed similar trends for the most part, with the high vapor pressure Philadelphia fuel exhibiting the largest changes in boiling temperatures. Distillation temperature increases for this fuel ranged to more than [illegible] between the 5- and 50-volume percent distilled points. Again, the larger [illegible] this fuel are attributable to losses of a large amount of butane [illegible] the original fuel.

Tables 3 through 12 are fuel compositions for the individual fuels. These are results of gas chromatographic analyses conducted on the initial and 48- hour samples. These GC data are presented as volume percent summations as a function of both carbon number and compound class. A listing of compound specific analyses for each summer and winter fuel, original and weathered, are contained in reference 1. In general, as might be expected, most of the changes occur in the $C_1$ to $C_5$ range containing the most volatile materials, i.e., butanes, and pentanes. Note that when reviewing tables 3 through 12, relative changes should be kept in mind; as one component decreases, the relative percentage of the others increase.

As an example, the 16.1 psi Philadelphia fuel exhibited the largest changes in vapor pressure, octane, and distillation character. Table 4 presents the compositional summaries from samples taken before and after weathering. By far, the largest total change is with the C4 compounds. The very high initial vapor pressure would suggest that the volatile materials lost were butane and isopentane. The specific component listing in reference 1 indicates a high initial butane content.

SUMMER GRADE FUELS.

The summer fuels tested were procured from geographic locations similar to those of the winter fuels. Both regular and premium unleaded gasolines were obtained, and as would be discovered, a gasohol fuel was included. Table 13 shows the effect of a controlled 110° F soak on the vapor pressures. Unweathered fuel RVP values were from about 8.5 to 11 psi. Decreases in vapor pressures due to weathering ranged from a low of 0.5 psi for Wichita samples to a high of 2.5 psi for Duluth. As with the winter fuels, most of the decreases occurred within 12 hours, and the drop in RVP appears to be marginally dependent on the initial RVP of the summer grade blends, with the fuel composition affecting the overall decline.

Octane quality changes are presented in table 14. Motor octane results showed no degradation for most of the fuels. Only the premium unleaded Sacramento fuel tests indicated a significant octane decrease of 0.7.

Figures 16 through 25 contain information on the summer fuel distillation character before and after weathering. For most cases, there were barely discernible differences in fuel boiling range due to weathering. IBP changes were minimal. The Houston fuel exhibited the most change with 5, 10, and 20 percent points increasing by about 10° F after weathering. This is not unexpected for these fuels since they contain far lower quantities of the more volatile front-end components normally used for vapor pressure enhancement. Specific alcohol analysis was conducted with the New Orleans fuel. Results showed 10-volume percent ethanol, thus accounting for the unusual shape of the distillation curves--the boiling point for ethanol is 173° F.

Tables 15 through 25 contain fuel compositional summaries for the summer fuels. As with the winter fuel results, the changes occur mostly in the front ends, from $C_1$ to $C_5$. Again, the specific component results for these fuels are contained in reference 1. It should be noted that the relatively small component losses for these fuels had essentially no effects on their octane and distillation characteristics.

## CONCLUSIONS

Tests were conducted to measure the effect of aging automobile gasoline on fuel volatility and octane characteristics. Winter and summer grade fuels were acquired from various locations in the continuous [illegible] to

It can be concluded that in most cases changes in automobile gasoline octane quality due to aging fuels at 110° F for 48 hours would be negligible for both summer and winter fuels. The only exceptions noted in these tests were due in one case to a relatively high butane concentration in the fuel and in another a sample container leaked following aging but prior to testing for the octane rating.

The magnitude of decrease in volatility, as characterized by Reid Vapor Pressure (RVP) was somewhat dependent on the initial test fuel RVP. However, fuels with similar initial vapor pressures do not necessarily age in a similar manner. Volatility decreases due to aging are dependent on the type and quantity of light hydrocarbon components found in the fuel.

Decreases in RVP due to aging, for both summer and winter fuels, occurred primarily during the 12-hour period following equilibration at 110° F. Changes occurring between 24 and 48 hours were within method repeatability.

Aging of the summer-grade fuels produced only minor increases in the distillation temperatures. Increases in the initial boiling point and distillation curve were more pronounced for the winter-grade fuels. These increases were most evident in the front end (low molecular weight-low boiling) point range of the distillation curve. The winter grade Philadelphia gasoline, which contained a very high butane concentration exhibited the greatest loss in volume. The changes measured in these experiments are similar to results from similar studies contained in references 2, 3, and 4.

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TABLE 1. - Vapor pressure versus time

| Fuel | Equivalent Reid Vapor Pressure (psi) | | | | |
|---|---|---|---|---|---|
| | Original | Time | | | |
| | | 0 | 12 | 24 | 48 |
| Houston, TX | 12.51 | 11.69 | 11.31 | 10.97 | 10.65 |
| Sacramento, CA | 12.51 | 11.46 | 10.99 | 11.10 | 10.61 |
| Philadelphia, PA | 16.14 | 12.11 | 11.37 | 11.16 | 10.78 |
| New Orleans, LA | 12.66 | 11.61 | 11.10 | 11.03 | 10.80 |
| Rockville, MD | 12.86 | 10.99 | 10.70 | 10.32 | 10.13 |
| San Diego, CA | 12.98 | 11.48 | 11.18 | 10.95 | 10.87 |
| Denver, CO | 14.06 | 12.36 | 11.73 | 11.27 | 10.84 |
| Wichita, KS | 14.08 | 12.08 | 11.69 | 11.54 | 11.37 |
| Ft. Lauderdale, FL | 11.98 | 10.19 | 10.15 | 10.04 | 9.81 |
| Chicago, IL | 13.93 | 11.82 | 11.44 | 11.37 | 10.87 |

TABLE 2. - Octane ratings

| Fuel | RON | | | MON | | |
|---|---|---|---|---|---|---|
| | Initial | Final | Diff. | Initial | Final | Diff. |
| Houston, TX | 91.6 | 91.5 | 0.1 | 82.6 | 82.4 | 0.2 |
| Sacramento, CA | 92.0 | 91.7 | 0.3 | 82.6 | 82.4 | 0.2 |
| Philadelphia, PA | 92.1 | 91.7 | 0.4 | 81.5 | 80.8 | 0.7 |
| New Orleans, LA | 92.3 | 92.3 | 0.0 | 86.2 | 86.1 | 0.1 |
| Rockville, MD | 91.7 | 91.4 | 0.3 | 82.3 | 82.2 | 0.1 |
| San Diego, CA | 92.3 | 92.1 | 0.2 | 82.8 | 82.5 | 0.3 |
| Denver, CO | 89.0 | 88.6 | 0.4 | 80.5 | 80.1 | 0.4 |
| Wichita, KS | 91.8 | 91.7 | 0.1 | 82.8 | 82.5 | 0.3 |
| Ft. Lauderdale, FL | 91.6 | 91.6 | 0.0 | 82.2 | 82.1 | 0.1 |
| Chicago, IL | 91.3 | 91.3 | 0.0 | 82.4 | 82.3 | 0.1 |

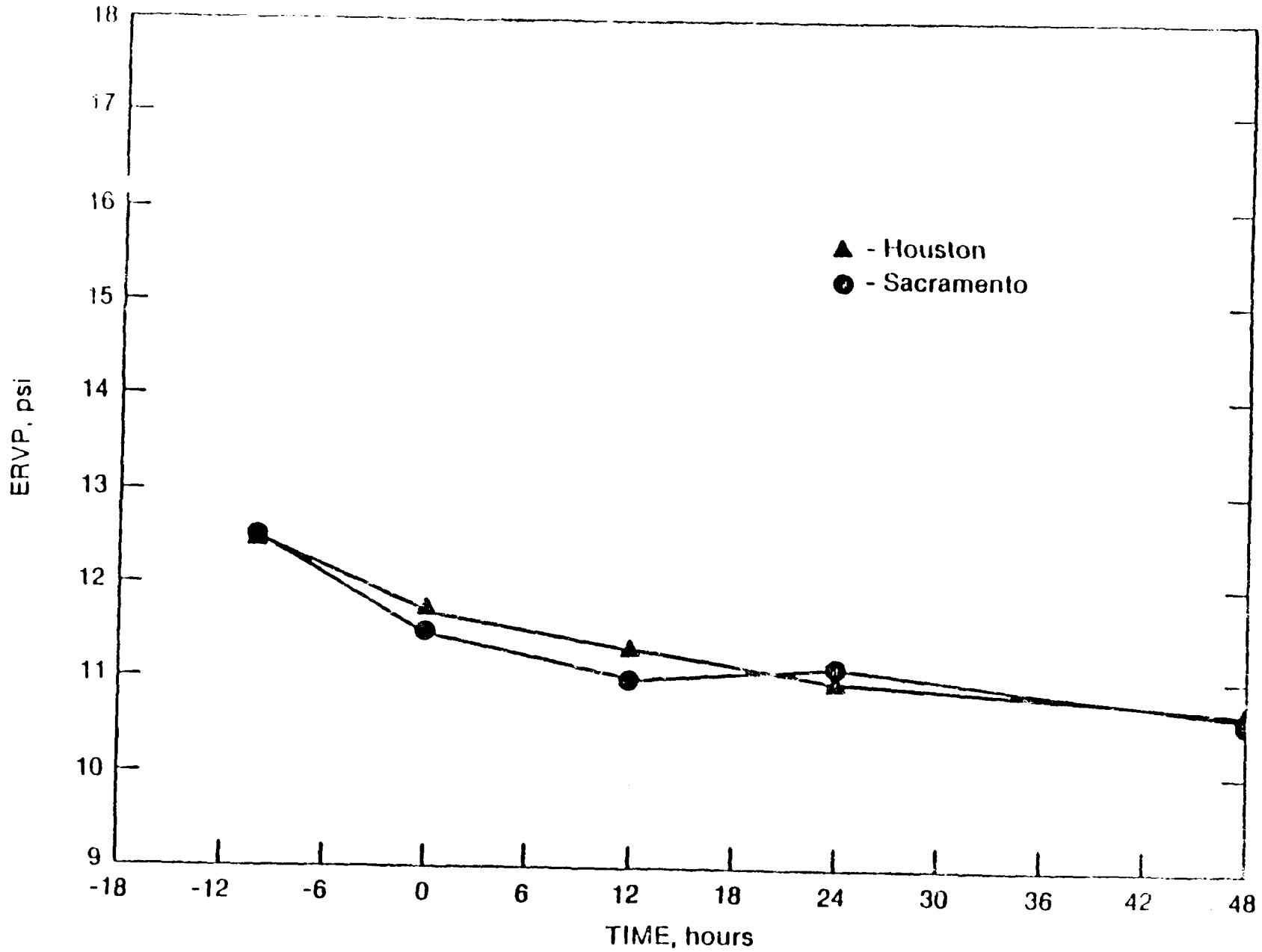


FIGURE 1. - Vapor pressure history, winter fuels from Houston and Sacramento.

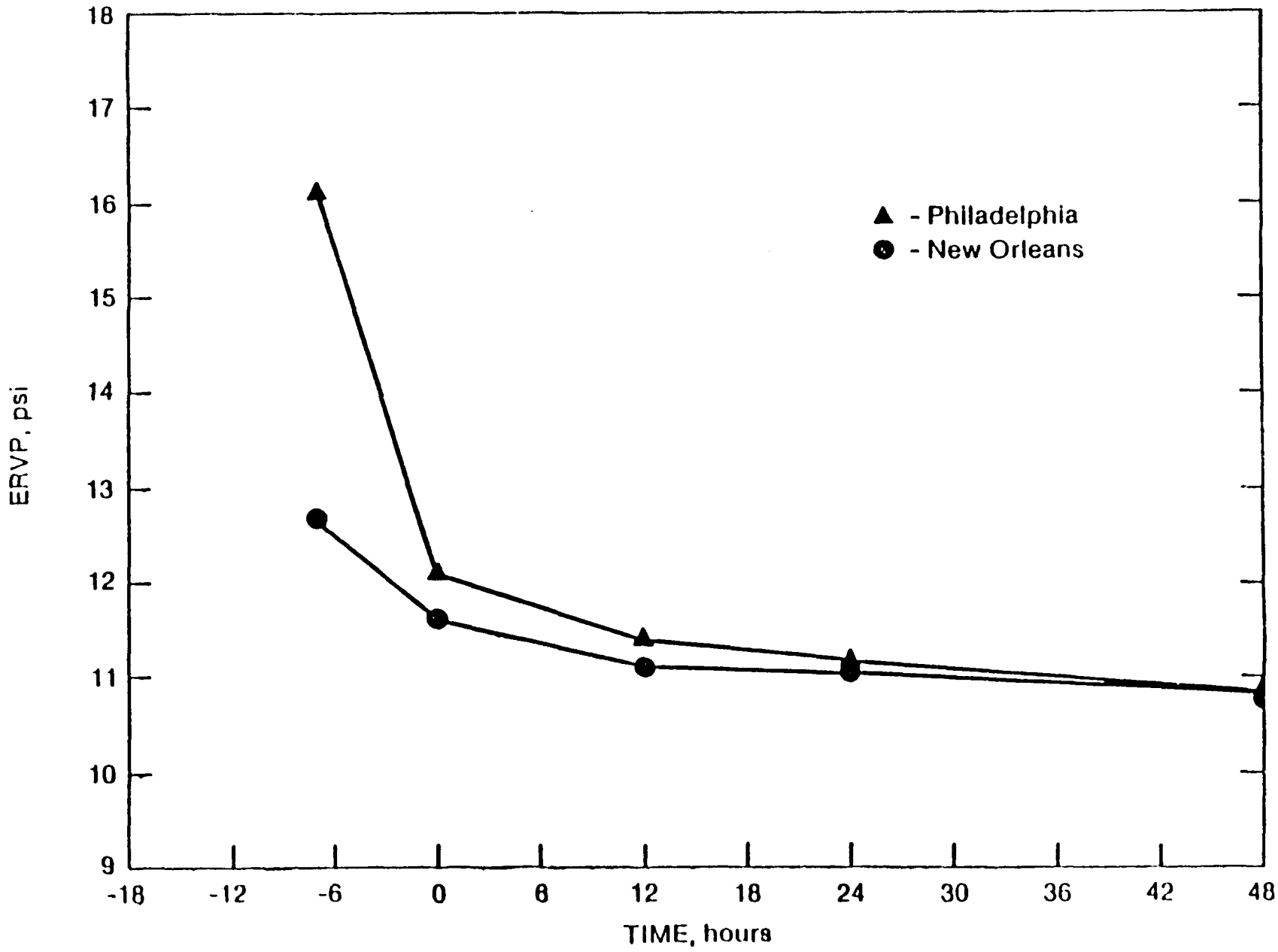


FIGURE 2. Vapor pressure history, winter fuels from

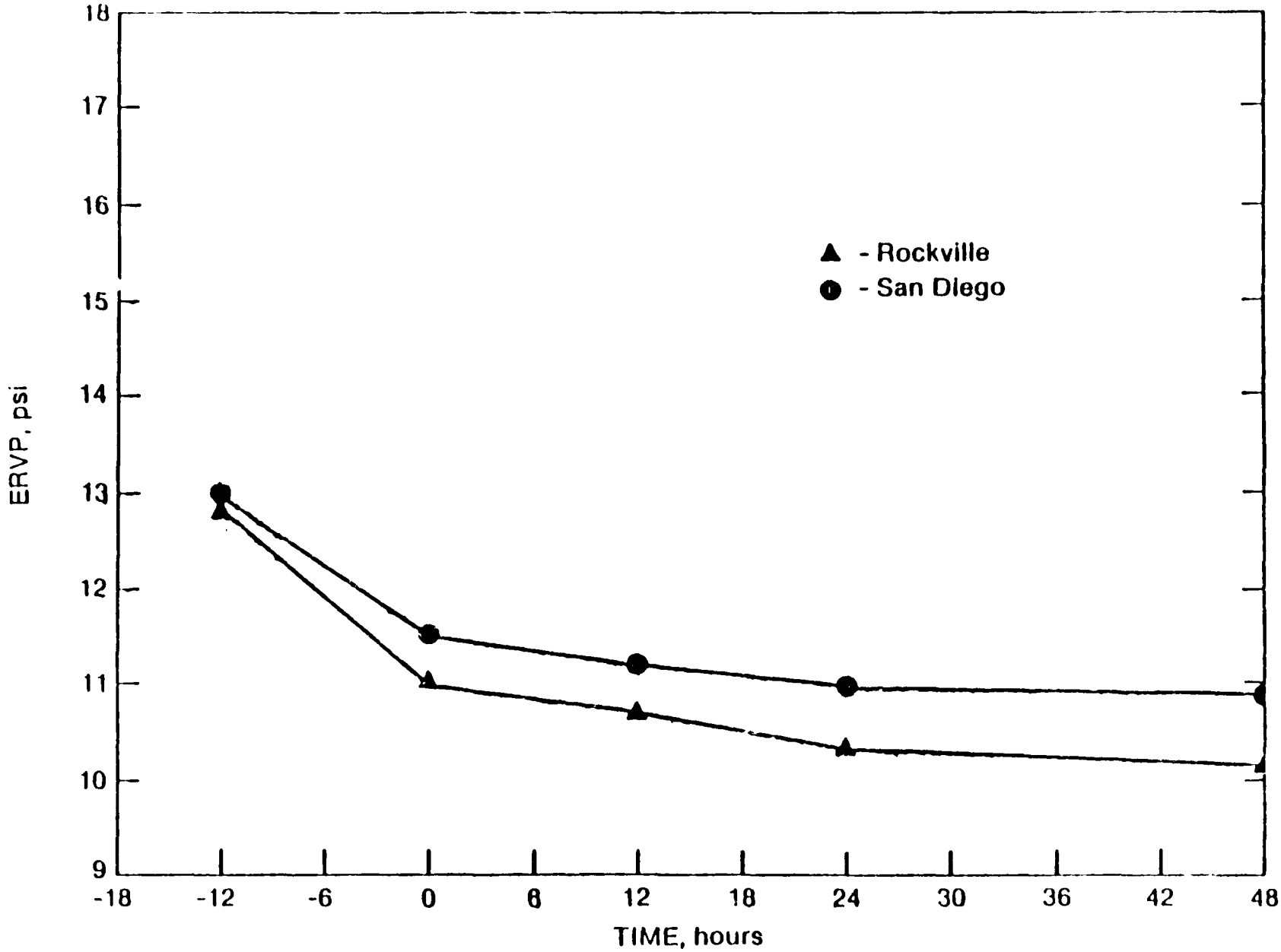


FIGURE 3. - Vapor pressure history, winter fuels from Rockville and San Diego.

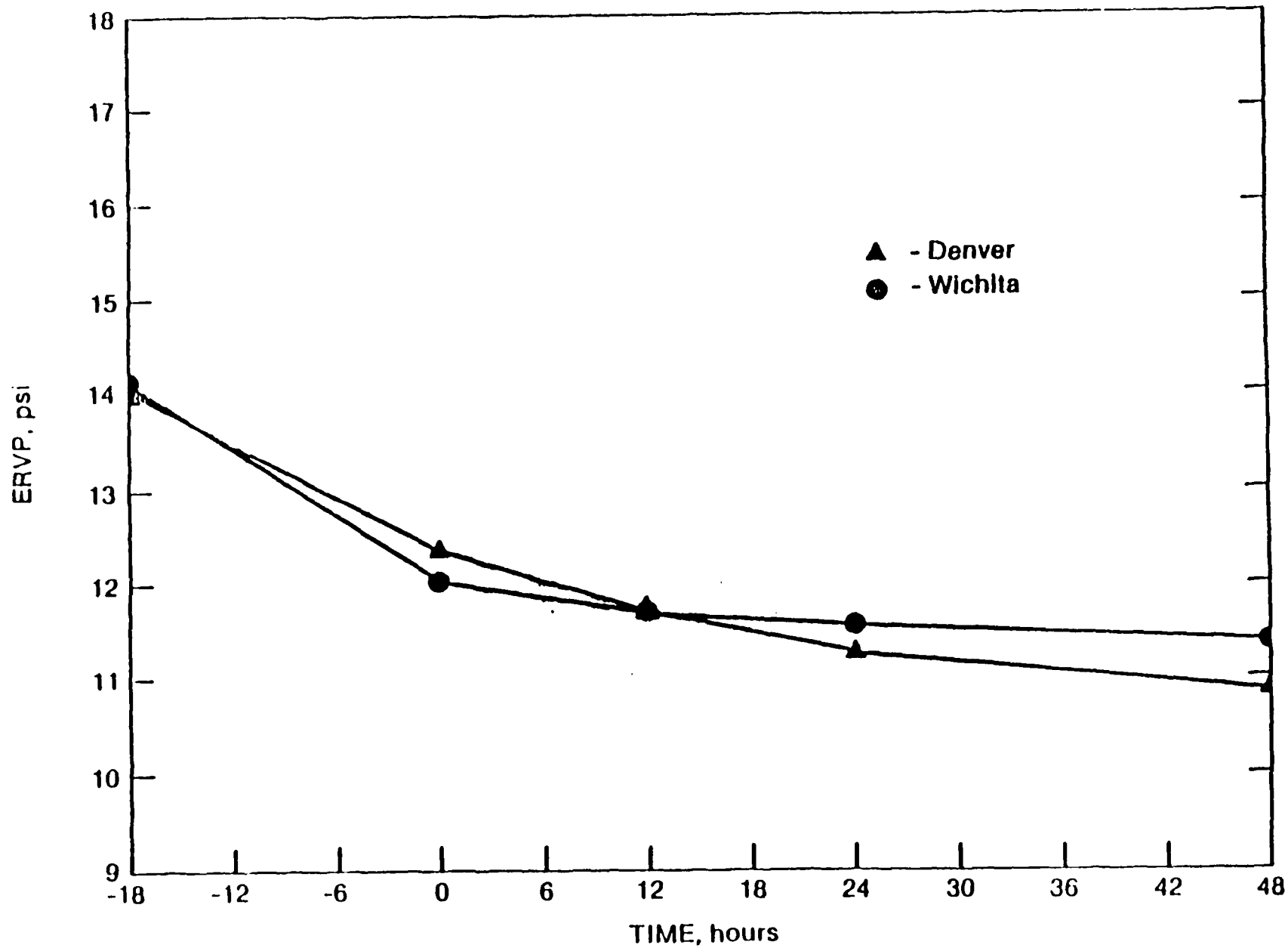


FIGURE 4. - Vapor pressure history, winter fuels from

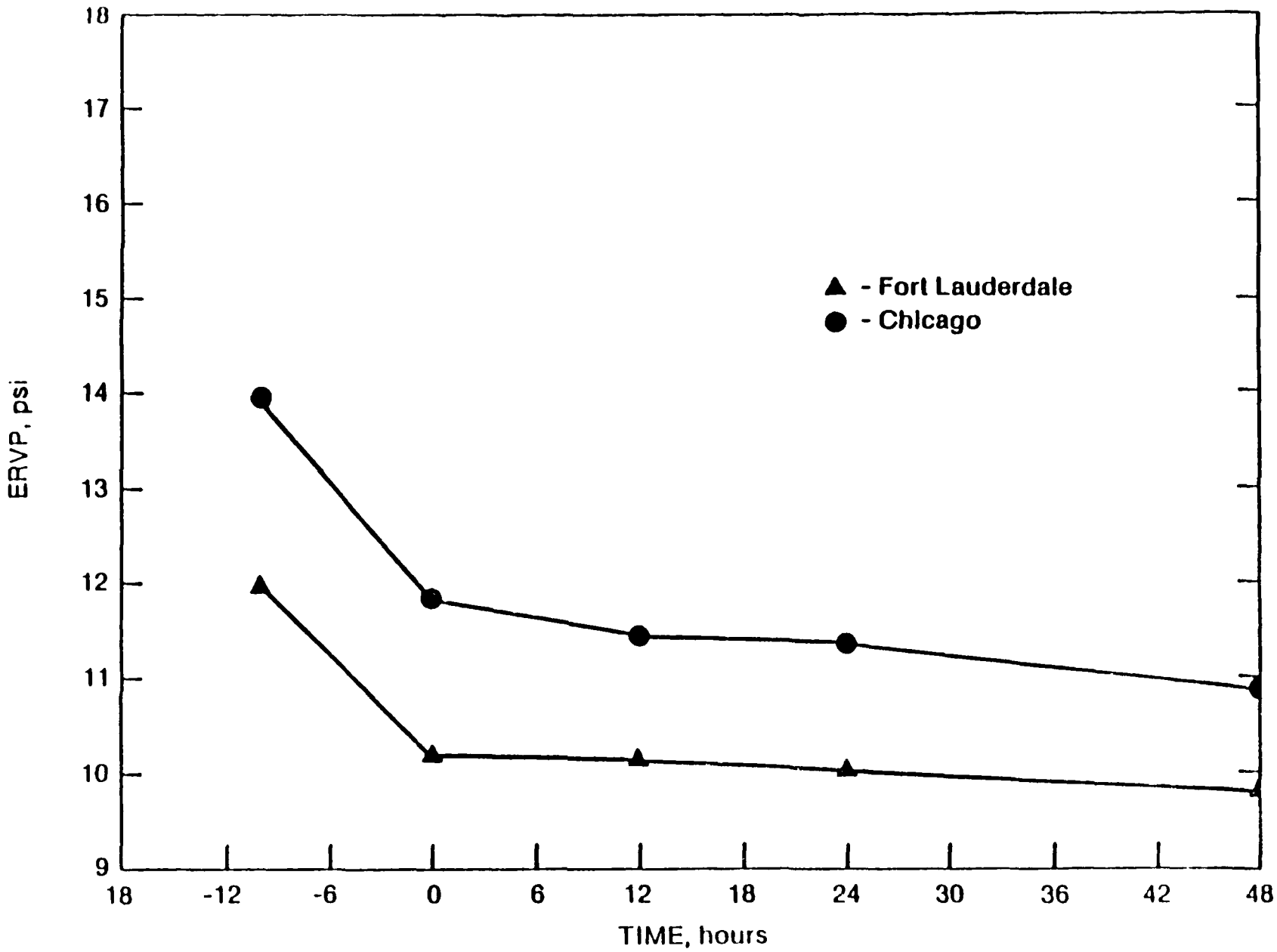


FIGURE 5. - Vapor pressure history, winter fuels from Ft. Lauderdale and Chicago.

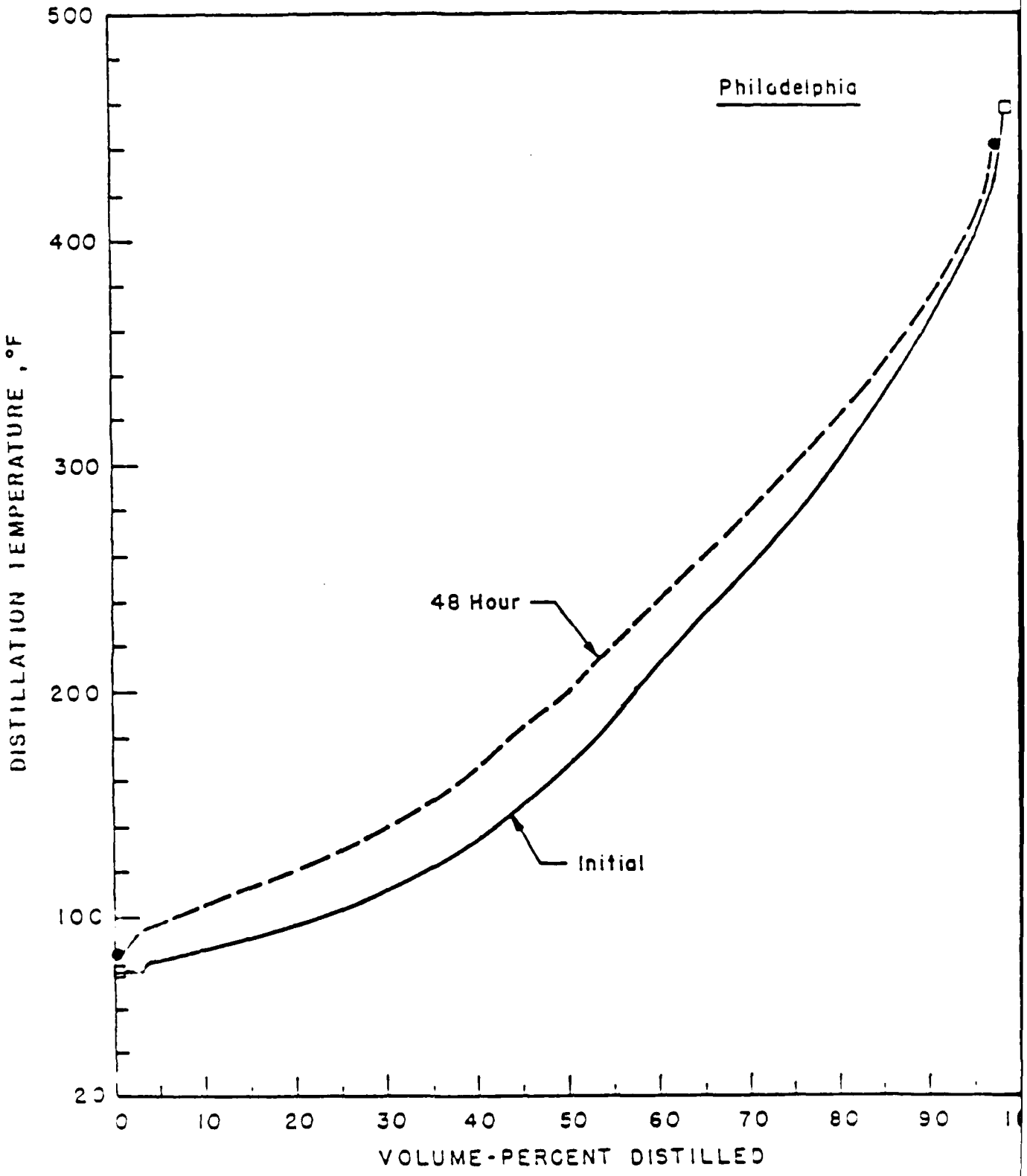


FIGURE 6. - Changes in distillation character due to weathering, winter fuels from Philadelphia.

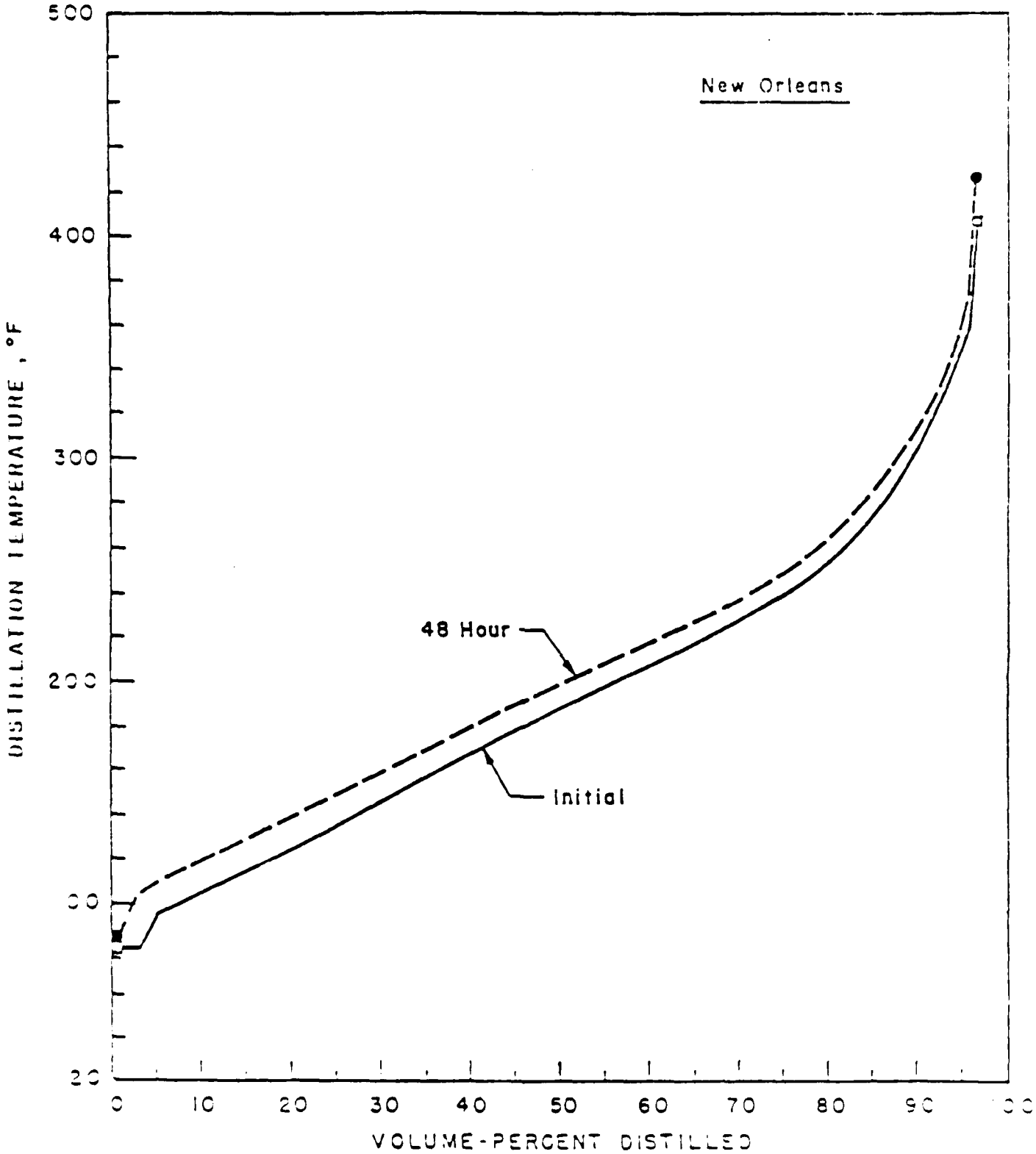


FIGURE 7. - Changes in distillation character due to weathering, winter fuels from New Orleans.

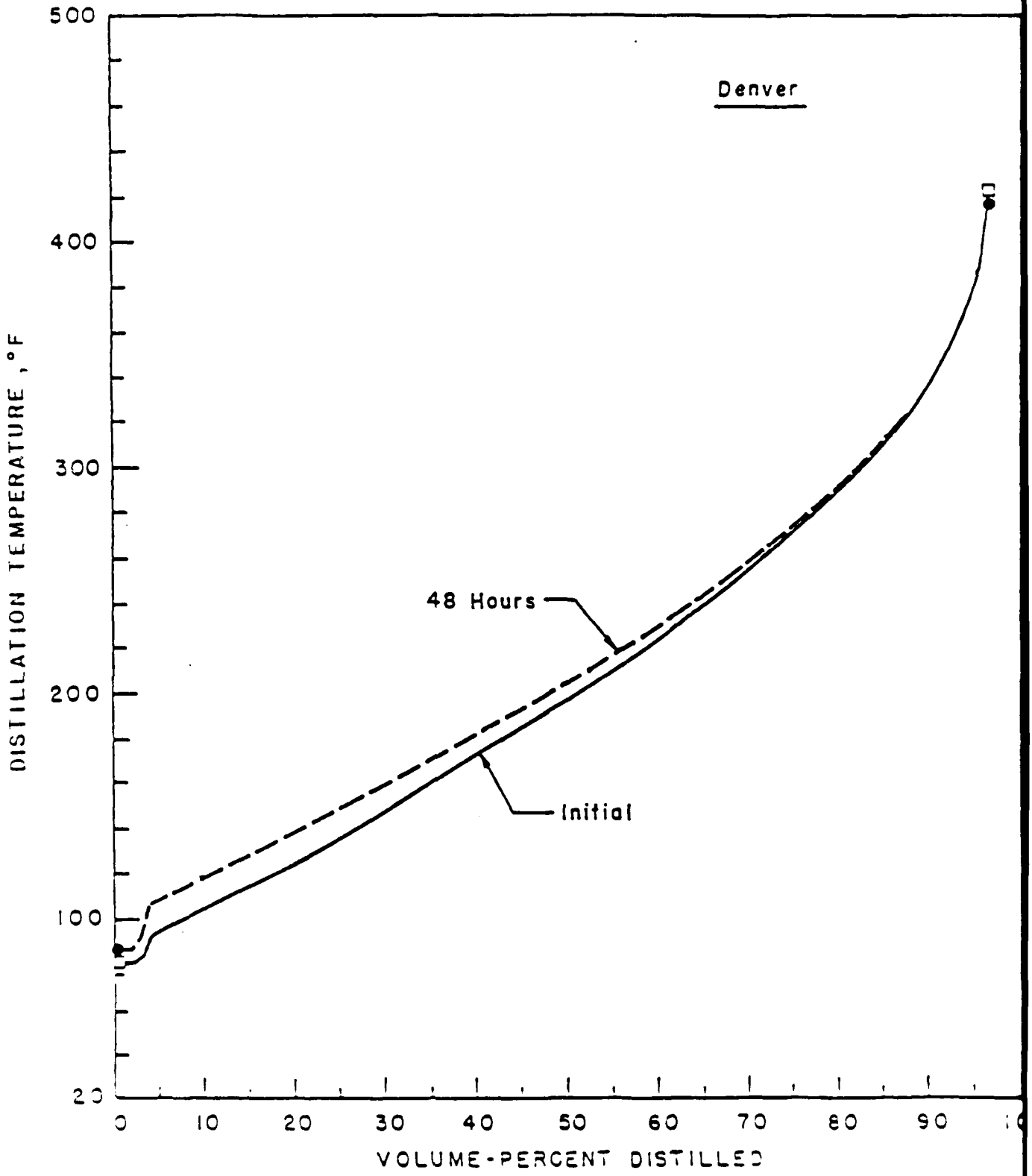


FIGURE 8. - Changes in distillation character due to weathering, winter fuels from Denver.

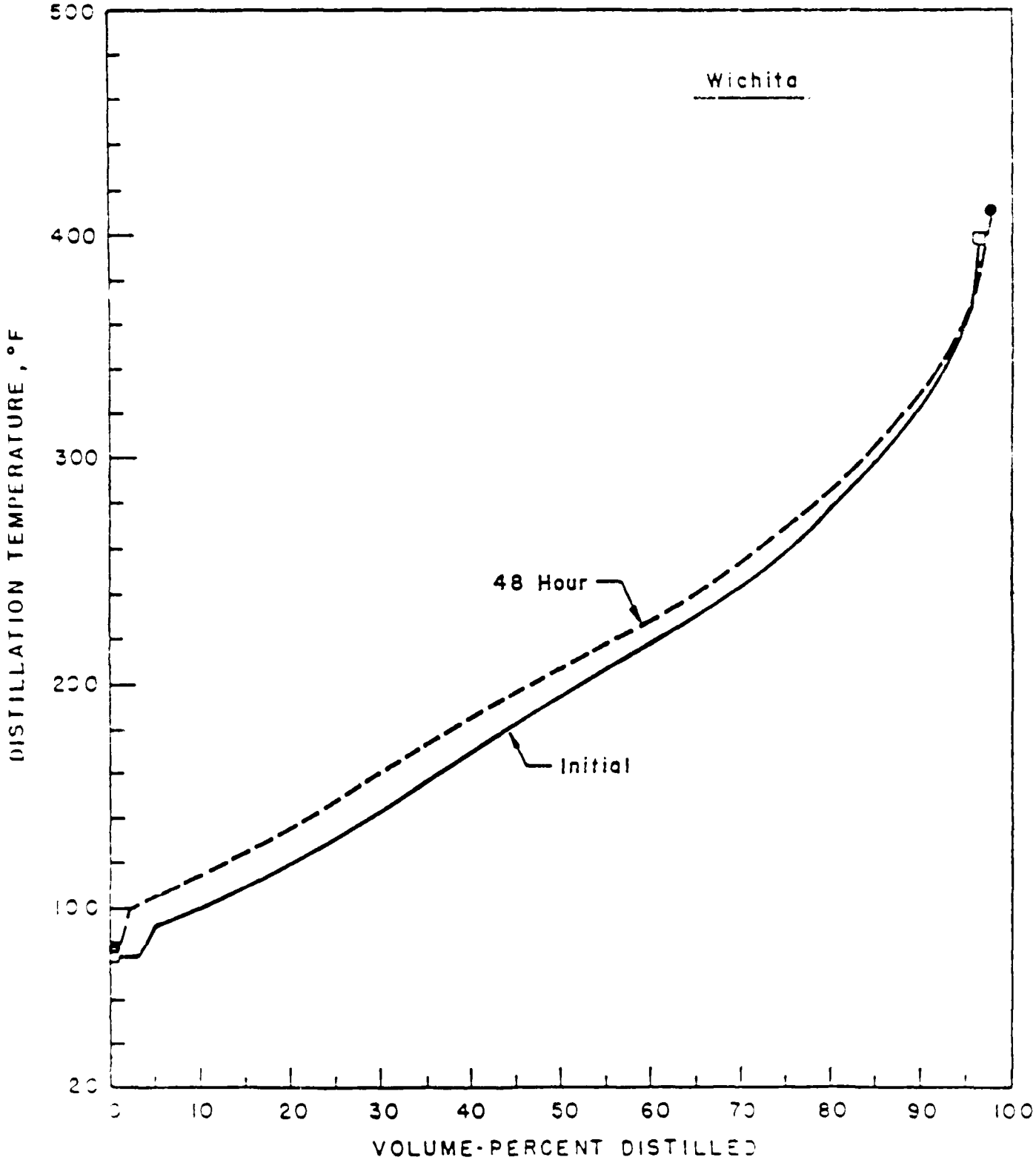


FIGURE 9. - Changes in distillation character due to weathering, winter fuels from Wichita.

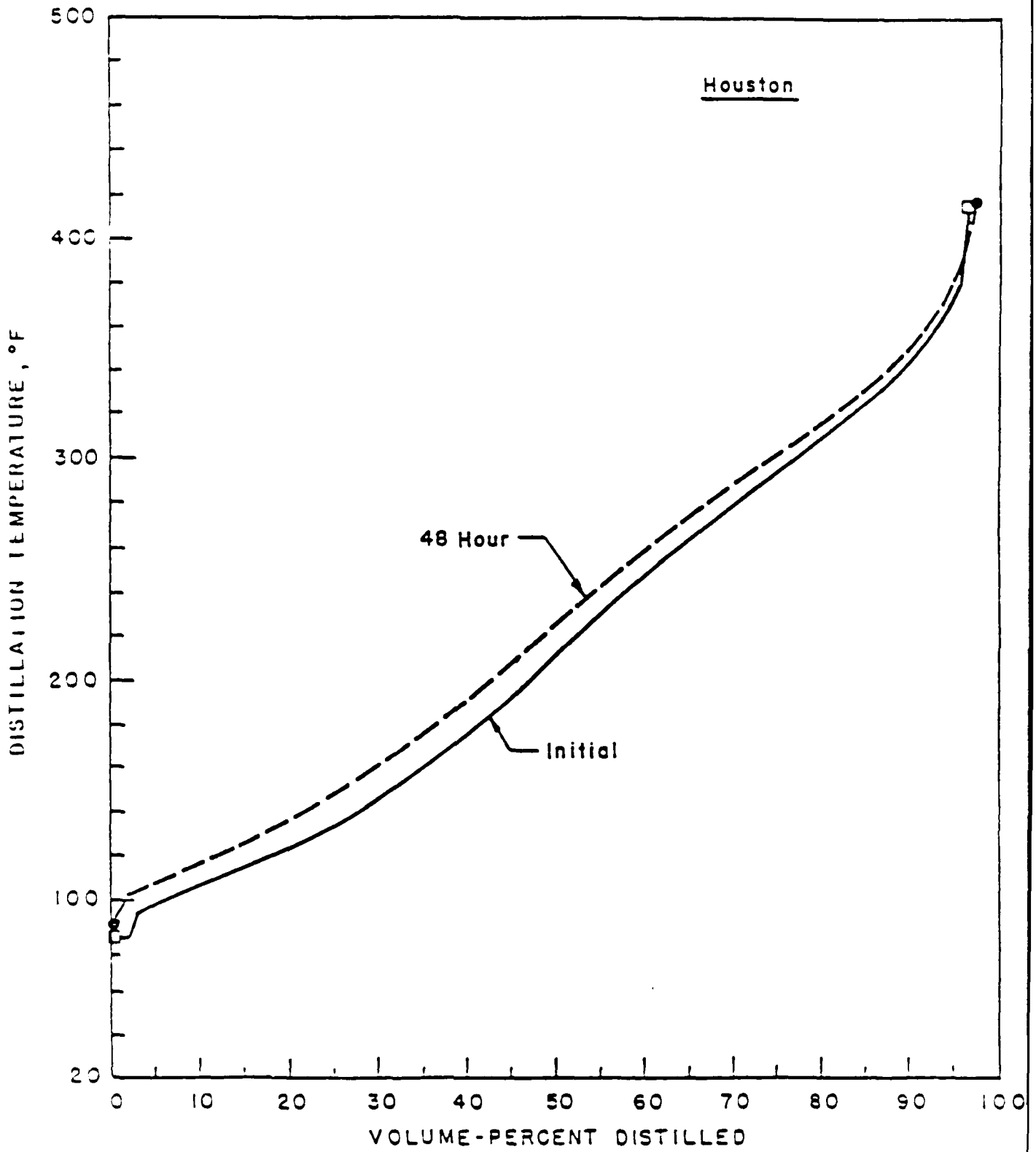


FIGURE 10. - Changes in distillation character due to weathering, winter fuels from Houston.

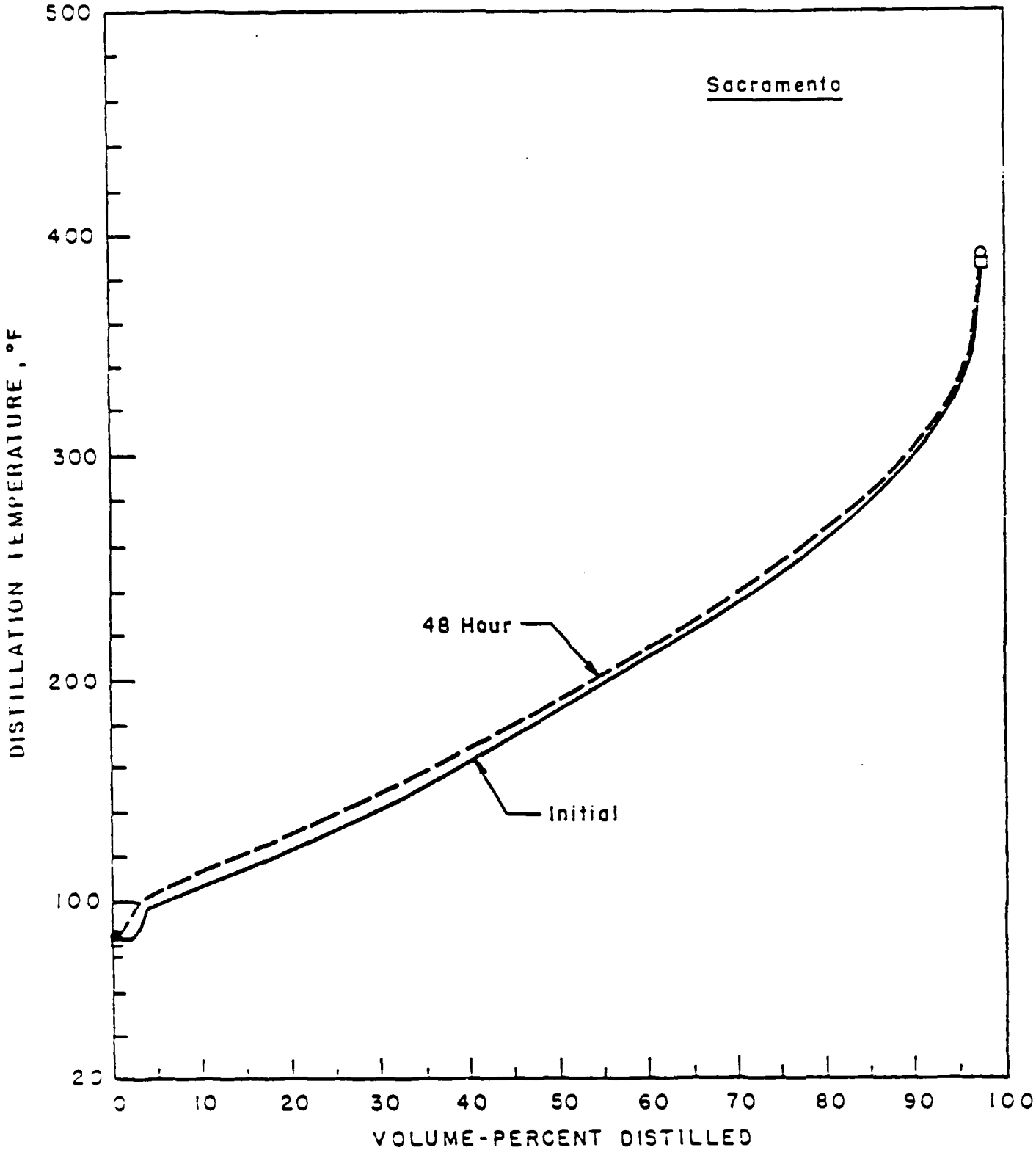


FIGURE 11. - Changes in distillation character due to weathering, winter fuels from Sacramento.

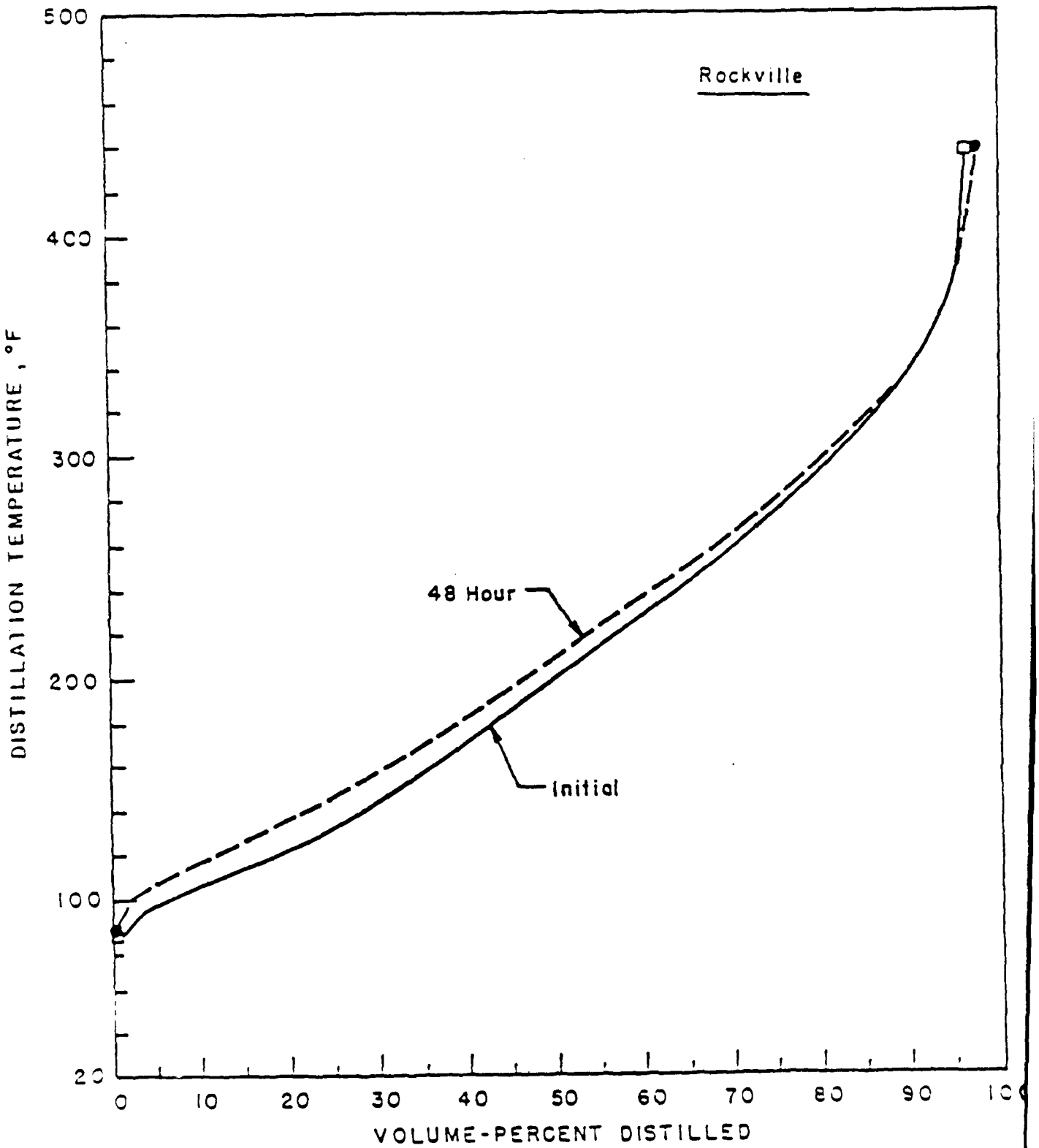


FIGURE 12. - Changes in distillation character due to weathering, winter fuels from Rockville.

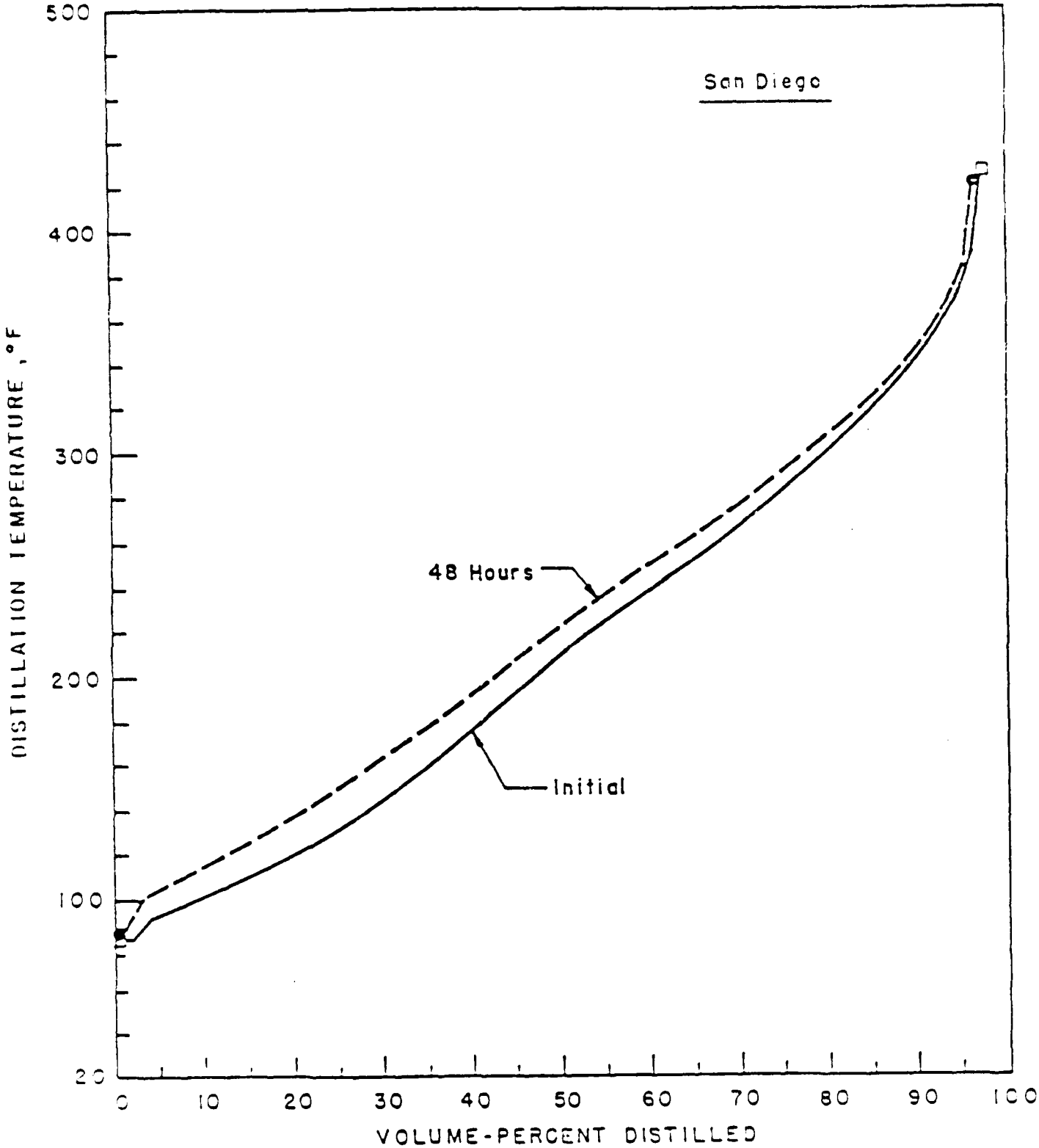


FIGURE 13. - Changes in distillation character due to weathering, winter fuels from San Diego.

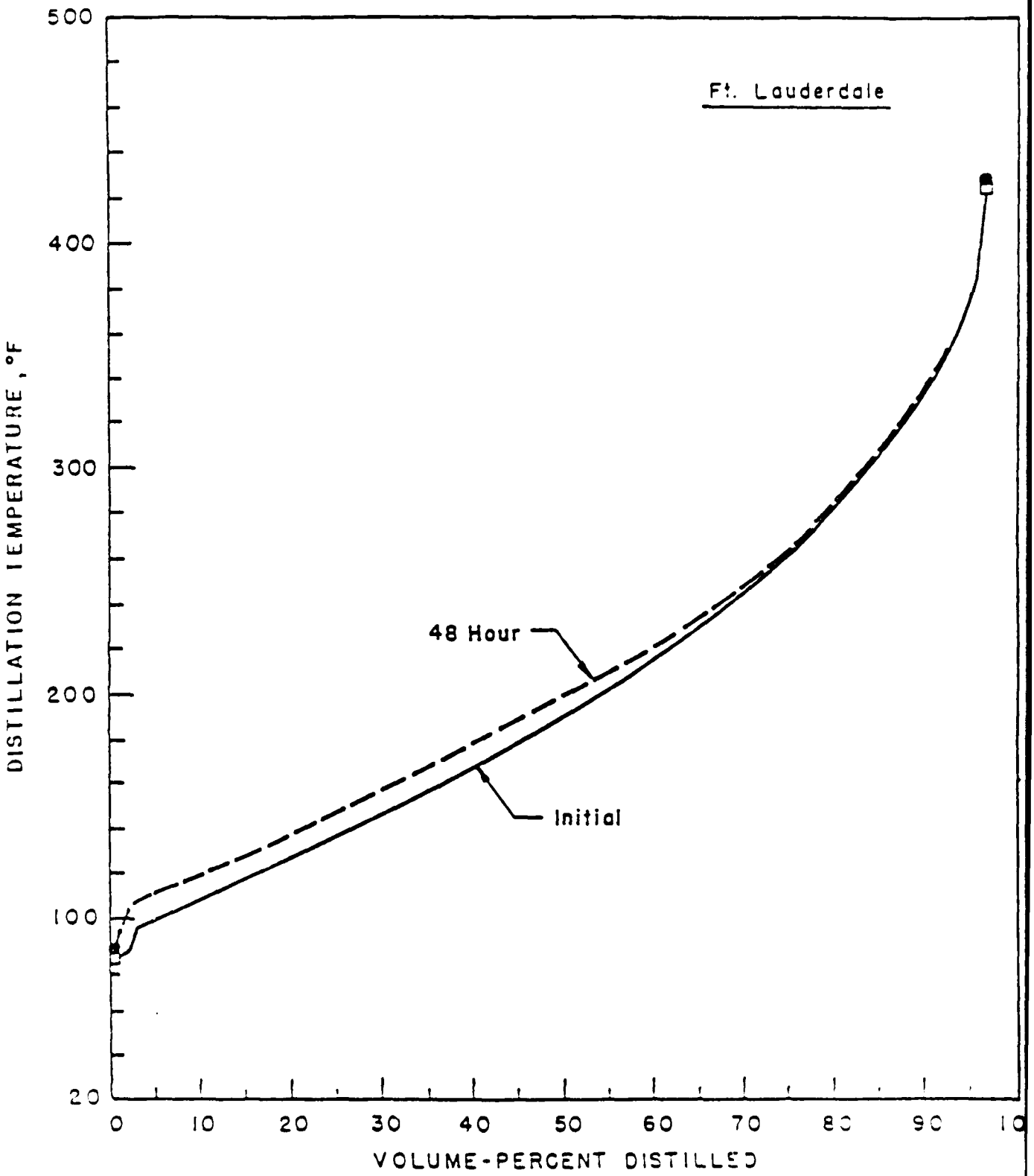


FIGURE 14. - Changes in distillation character due to weathering, winter fuels from Ft. Lauderdale.

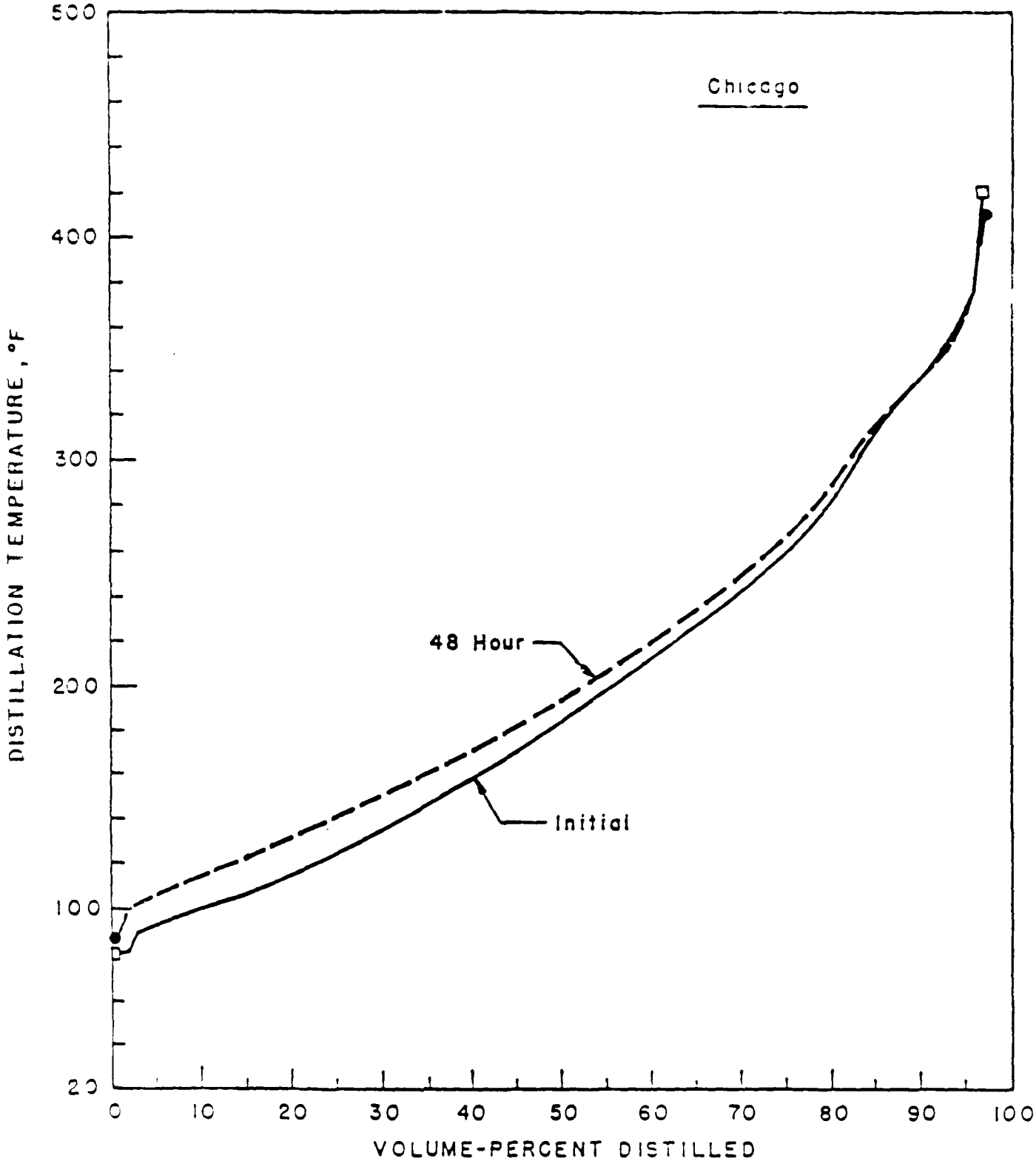


FIGURE 15. - Changes in distillation character due to weathering, winter fuels from Chicago.

TABLE 3. - Fuel composition summary - New Orleans - winter

Volume-percent Summation by Carbon Number and Compound Class

Initial

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.12 | 0.00 | 0.00 | 0.02 | 0.00 | 0.13 |
| 4 | 9.54 | 2.26 | 0.00 | 0.88 | 0.00 | 12.69 |
| 5 | 5.94 | 8.65 | 0.12 | 4.52 | 0.00 | 19.23 |
| 6 | 4.27 | 8.01 | 1.42 | 1.51 | 1.03 | 16.24 |
| 7 | 1.47 | 8.41 | 2.10 | 2.68 | 3.68 | 18.33 |
| 8 | 0.57 | 16.88 | 0.69 | 0.03 | 4.45 | 22.63 |
| 9 | 0.12 | 2.83 | 0.04 | 0.00 | 3.06 | 6.05 |
| 10 | 0.05 | 2.20 | 0.00 | 0.00 | 2.22 | 4.47 |
| 11 | 0.05 | 0.02 | 0.00 | 0.00 | 0.15 | 0.22 |
| 12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total | 22.13 | 49.27 | 4.36 | 9.64 | 14.60 | 100.00 |

Average Molecular Weight = 88.64
Average Density - .702
Average Carbon Number = 6.29
H/C Ratio = 2.06

48 Hours

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.05 | 0.00 | 0.00 | 0.01 | 0.00 | 0.06 |
| 4 | 7.55 | 1.59 | 0.00 | 0.70 | 0.00 | 9.85 |
| 5 | 5.65 | 8.00 | 0.11 | 4.57 | 0.00 | 18.33 |
| 6 | 4.26 | 7.93 | 1.43 | 1.53 | 1.11 | 16.25 |
| 7 | 1.50 | 8.45 | 2.10 | 2.72 | 4.01 | 18.78 |
| 8 | 0.59 | 19.48 | 0.87 | 0.04 | 4.61 | 25.59 |
| 9 | 0.12 | 3.14 | 0.00 | 0.00 | 3.19 | 6.45 |
| 10 | 0.05 | 2.28 | 0.00 | 0.00 | 2.15 | 4.48 |
| 11 | 0.05 | 0.02 | 0.00 | 0.00 | 0.14 | 0.21 |
| 12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total | 19.82 | 50.87 | 4.51 | 9.57 | 15.21 | 100.00 |

Average Molecular Weight = 90.69
Average Density - .708
Average Carbon Number = 6.44
H/C Ratio = 2.04

TABLE 4. - Fuel composition summary - Chicago - winter

Volume-percent Summation by Carbon Number and Compound Class

Initial

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.17 | 0.00 | 0.00 | 0.02 | 0.00 | 0.18 |
| 4 | 11.68 | 1.57 | 0.00 | 1.35 | 0.00 | 14.60 |
| 5 | 6.23 | 10.56 | 0.19 | 4.29 | 0.00 | 21.28 |
| 6 | 3.12 | 11.44 | 2.57 | 1.74 | 1.76 | 20.63 |
| 7 | 1.73 | 4.56 | 1.26 | 2.07 | 9.02 | 18.65 |
| 8 | 0.58 | 5.75 | 1.17 | 0.10 | 3.18 | 10.78 |
| 9 | 0.14 | 1.04 | 0.00 | 0.00 | 7.56 | 8.73 |
| 10 | 0.10 | 0.20 | 0.00 | 0.00 | 4.22 | 4.53 |
| 11 | 0.10 | 0.03 | 0.00 | 0.00 | 0.49 | 0.62 |
| 12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total | 23.85 | 35.15 | 5.19 | 9.58 | 26.23 | 100.00 |

Average Molecular Weight = 85.92
Average Density - .715
Average Carbon Number = 6.16
H/C Ratio = 1.93

48 Hours

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 |
| 4 | 7.98 | 0.88 | 0.00 | 0.93 | 0.00 | 9.79 |
| 5 | 5.82 | 9.48 | 0.19 | 4.01 | 0.00 | 19.49 |
| 6 | 4.19 | 11.73 | 2.78 | 2.49 | 1.87 | 23.06 |
| 7 | 1.88 | 4.96 | 1.37 | 2.28 | 9.89 | 20.39 |
| 8 | 0.63 | 6.41 | 0.77 | 0.11 | 3.55 | 11.48 |
| 9 | 0.15 | 1.23 | 0.00 | 0.00 | 8.35 | 9.74 |
| 10 | 0.12 | 0.26 | 0.00 | 0.00 | 4.75 | 5.12 |
| 11 | 0.11 | 0.03 | 0.00 | 0.00 | 0.73 | 0.87 |
| 12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total | 20.93 | 34.98 | 5.11 | 9.82 | 29.14 | 100.00 |

Average Molecular Weight = 88.87
Average Density - .727
Average Carbon Number = 6.39
H/C Ratio = 1.88

TABLE 5. - Fuel composition summary - Ft. Lauderdale - winter

Volume-percent Summation by Carbon Number and Compound Class

Initial

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.14 | 0.00 | 0.00 | 0.05 | 0.00 | 0.19 |
| 4 | 8.12 | 1.59 | 0.00 | 1.20 | 0.00 | 10.92 |
| 5 | 5.78 | 10.71 | 0.17 | 4.19 | 0.00 | 20.85 |
| 6 | 3.40 | 10.87 | 2.64 | 3.04 | 2.29 | 22.25 |
| 7 | 1.66 | 5.75 | 1.52 | 2.59 | 8.31 | 19.83 |
| 8 | 0.45 | 5.92 | 0.77 | 0.06 | 6.45 | 13.65 |
| 9 | 0.12 | 1.63 | 0.02 | 0.00 | 6.09 | 7.86 |
| 10 | 0.08 | 0.25 | 0.00 | 0.00 | 3.67 | 4.00 |
| 11 | 0.07 | 0.00 | 0.00 | 0.00 | 0.40 | 0.46 |
| 12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total | 19.81 | 36.73 | 5.12 | 11.13 | 27.21 | 100.00 |

Average Molecular Weight = 87.39
Average Density - .720
Average Carbon Number = 6.27
H/C Ratio = 1.90

48 Hours

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.06 | 0.00 | 0.00 | 0.02 | 0.00 | 0.08 |
| 4 | 5.41 | 1.10 | 0.00 | 0.92 | 0.00 | 7.43 |
| 5 | 5.42 | 10.00 | 0.17 | 4.03 | 0.00 | 19.61 |
| 6 | 3.37 | 10.79 | 2.72 | 3.25 | 2.56 | 22.68 |
| 7 | 1.71 | 6.44 | 1.75 | 2.88 | 8.46 | 21.24 |
| 8 | 0.42 | 6.32 | 0.89 | 0.08 | 8.12 | 15.83 |
| 9 | 0.12 | 2.10 | 0.06 | 0.00 | 5.86 | 8.14 |
| 10 | 0.07 | 0.37 | 0.00 | 0.00 | 3.59 | 4.03 |
| 11 | 0.05 | 0.13 | 0.00 | 0.00 | 0.72 | 0.90 |
| 12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.05 |
| Total | 16.61 | 37.25 | 5.59 | 11.19 | 29.36 | 100.00 |

Average Molecular Weight = 89.78
Average Density - .730
Average Carbon Number = 6.46
H/C Ratio = 1.87

TABLE 6. - Fuel composition summary - Philadelphia - winter

Volume-percent Summation by Carbon Number and Compound Class

Initial

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.06 | 0.00 | 0.00 | 0.01 | 0.00 | 0.07 |
| 4 | 9.23 | 3.19 | 0.00 | 5.09 | 0.00 | 17.51 |
| 5 | 9.55 | 12.86 | 0.24 | 6.77 | 0.00 | 29.43 |
| 6 | 1.70 | 6.46 | 1.61 | 5.27 | 0.44 | 15.49 |
| 7 | 0.85 | 2.90 | 1.42 | 3.62 | 3.50 | 12.29 |
| 8 | 0.37 | 3.34 | 1.65 | 0.16 | 5.21 | 10.74 |
| 9 | 0.14 | 2.89 | 0.09 | 0.00 | 4.96 | 8.08 |
| 10 | 0.11 | 0.70 | 0.00 | 0.00 | 3.97 | 4.78 |
| 11 | 0.15 | 0.08 | 0.00 | 0.00 | 0.89 | 1.13 |
| 12 | 0.15 | 0.16 | 0.00 | 0.00 | 0.18 | 0.48 |
| Total | 22.31 | 32.59 | 5.02 | 20.93 | 19.15 | 100.00 |

Average Molecular Weight = 83.51
Average Density - .699
Average Carbon Number = 5.96
H/C Ratio = 1.99

48 Hours

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| 4 | 4.77 | 1.13 | 0.00 | 2.60 | 0.00 | 8.50 |
| 5 | 8.95 | 11.01 | 0.25 | 6.31 | 0.00 | 26.53 |
| 6 | 1.93 | 7.08 | 1.86 | 5.95 | 0.51 | 17.33 |
| 7 | 1.04 | 3.46 | 1.75 | 4.34 | 4.40 | 14.98 |
| 8 | 0.39 | 4.21 | 2.16 | 0.26 | 6.47 | 13.48 |
| 9 | 0.17 | 3.61 | 0.12 | 0.00 | 6.33 | 10.23 |
| 10 | 0.14 | 0.96 | 0.00 | 0.00 | 4.99 | 6.08 |
| 11 | 0.20 | 0.08 | 0.00 | 0.00 | 1.69 | 1.97 |
| 12 | 0.19 | 0.00 | 0.00 | 0.00 | 0.70 | 0.90 |
| Total | 17.78 | 31.54 | 6.13 | 19.46 | 25.09 | 100.00 |

Average Molecular Weight = 89.77
Average Density - .723
Average Carbon Number = 6.44
H/C Ratio = 1.91

TABLE 7. - Fuel composition summary - San Diego - winter

Volume-percent Summation by Carbon Number and Compound Class

Initial

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.12 | 0.00 | 0.00 | 0.03 | 0.00 | 0.15 |
| 4 | 7.41 | 3.97 | 0.00 | 0.74 | 0.00 | 12.12 |
| 5 | 4.64 | 10.29 | 0.19 | 4.84 | 0.00 | 19.96 |
| 6 | 2.57 | 7.20 | 2.33 | 3.22 | 1.25 | 16.57 |
| 7 | 1.37 | 4.68 | 3.17 | 0.54 | 6.28 | 16.05 |
| 8 | 0.78 | 6.61 | 1.22 | 0.01 | 9.12 | 17.75 |
| 9 | 0.38 | 3.14 | 0.11 | 0.00 | 7.19 | 10.82 |
| 10 | 0.25 | 1.02 | 0.00 | 0.00 | 4.46 | 5.72 |
| 11 | 0.14 | 0.03 | 0.00 | 0.00 | 0.48 | 0.64 |
| 12 | 0.00 | 0.06 | 0.00 | 0.00 | 0.15 | 0.22 |
| Total | 17.65 | 37.00 | 7.03 | 9.39 | 28.93 | 100.00 |

Average Molecular Weight = 89.52
Average Density - .726
Average Carbon Number = 6.43
H/C Ratio = 1.89

48 Hours

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.05 | 0.00 | 0.00 | 0.01 | 0.00 | 0.06 |
| 4 | 6.00 | 2.85 | 0.00 | 0.60 | 0.00 | 9.45 |
| 5 | 4.52 | 9.69 | 0.20 | 4.69 | 0.00 | 19.10 |
| 6 | 2.64 | 7.32 | 2.35 | 3.28 | 1.30 | 16.90 |
| 7 | 1.45 | 4.88 | 3.31 | 0.58 | 6.58 | 16.79 |
| 8 | 0.82 | 6.94 | 1.00 | 0.01 | 9.60 | 18.37 |
| 9 | 0.40 | 3.21 | 0.16 | 0.00 | 7.61 | 11.37 |
| 10 | 0.26 | 1.43 | 0.00 | 0.00 | 4.90 | 6.59 |
| 11 | 0.15 | 0.17 | 0.00 | 0.00 | 0.63 | 0.95 |
| 12 | 0.00 | 0.11 | 0.00 | 0.00 | 0.30 | 0.41 |
| Total | 16.29 | 36.61 | 7.01 | 9.18 | 30.91 | 100.00 |

Average Molecular Weight = 91.61
Average Density - .734
Average Carbon Number = 6.60
H/C Ratio = 1.86

TABLE 8. - Fuel composition summary - Rockville - winter

Volume-percent Summation by Carbon Number and Compound Class

Initial

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.19 | 0.00 | 0.00 | 0.03 | 0.00 | 0.22 |
| 4 | 7.41 | 1.77 | 0.00 | 2.54 | 0.00 | 11.72 |
| 5 | 7.00 | 10.49 | 0.18 | 4.80 | 0.00 | 22.48 |
| 6 | 2.47 | 8.54 | 1.66 | 3.64 | 1.21 | 17.52 |
| 7 | 1.22 | 5.72 | 2.07 | 1.40 | 5.70 | 16.11 |
| 8 | 0.52 | 7.65 | 1.59 | 0.07 | 7.04 | 16.87 |
| 9 | 0.35 | 3.01 | 0.08 | 0.00 | 6.41 | 9.87 |
| 10 | 0.25 | 0.83 | 0.00 | 0.00 | 3.69 | 4.77 |
| 11 | 0.11 | 0.03 | 0.00 | 0.00 | 0.29 | 0.43 |
| 12 | 0.00 | 0.01 | 0.00 | 0.00 | 0.03 | 0.03 |
| Total | 19.52 | 38.05 | [illegible] | 12.48 | [illegible] | 100.00 |

Average Molecular Weight = 88.15
Average Density - .716
Average Carbon Number = 6.31
H/C Ratio = 1.94

48 Hours

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.06 | 0.00 | 0.00 | 0.01 | 0.00 | 0.07 |
| 4 | 5.46 | 1.09 | 0.00 | 1.86 | 0.00 | 8.41 |
| 5 | 6.83 | 9.78 | 0.18 | 4.71 | 0.00 | 21.51 |
| 6 | 2.63 | 8.94 | 1.78 | 3.86 | 1.31 | 18.53 |
| 7 | 1.32 | 6.24 | 2.36 | 1.45 | 6.20 | 17.58 |
| 8 | 0.59 | 9.12 | 0.98 | 0.06 | 7.52 | 18.27 |
| 9 | 0.38 | 2.73 | 0.09 | 0.00 | 6.72 | 9.92 |
| 10 | 0.24 | 1.01 | 0.00 | 0.00 | 4.00 | 5.25 |
| 11 | 0.11 | 0.03 | 0.00 | 0.00 | 0.32 | 0.47 |
| 12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total | [illegible] | 38.94 | 5.39 | 11.95 | 26.07 | [illegible] |

Average Molecular Weight = 90.25
Average Density - .724
Average Carbon Number = 6.47
H/C Ratio = 1.91

TABLE 9. - Fuel composition summary - Sacramento - winter

Volume-percent Summation by Carbon Number and Compound Class

Initial

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.24 | 0.00 | 0.00 | 0.00 | 0.00 | 0.24 |
| 4 | 5.93 | 2.87 | 0.00 | 0.97 | 0.00 | 9.77 |
| 5 | 5.75 | 13.15 | 0.22 | 3.34 | 0.00 | 22.46 |
| 6 | 2.75 | 10.84 | 3.81 | 3.37 | 1.64 | 22.42 |
| 7 | 1.12 | 5.51 | 3.10 | 1.28 | 6.00 | 17.00 |
| 8 | 0.38 | 7.09 | 1.90 | 0.06 | 7.80 | 17.22 |
| 9 | 0.21 | 3.01 | 0.07 | 0.00 | 4.95 | 8.23 |
| 10 | 0.09 | 0.36 | 0.00 | 0.00 | 2.06 | 2.50 |
| 11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.15 | 0.15 |
| 12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total | 16.46 | 42.84 | 9.10 | 9.01 | 22.59 | 100.00 |

Average Molecular Weight = 87.54
Average Density - .714
Average Carbon Number = 6.26
H/C Ratio = 1.96

48 Hours

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.12 |
| 4 | 5.00 | 2.17 | 0.00 | 0.82 | 0.00 | 7.99 |
| 5 | 5.71 | 12.67 | 0.23 | 3.32 | 0.00 | 21.92 |
| 6 | 2.87 | 11.15 | 3.96 | 3.24 | 1.70 | 22.92 |
| 7 | 1.18 | 5.67 | 1.61 | 2.82 | 6.25 | 17.53 |
| 8 | 0.35 | 8.55 | 1.26 | 0.03 | 8.12 | 18.31 |
| 9 | 0.11 | 3.02 | 0.07 | 0.00 | 5.22 | 8.42 |
| 10 | 0.00 | 0.41 | 0.00 | 0.00 | 2.23 | 2.65 |
| 11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.14 | 0.14 |
| 12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total | 15.33 | 43.65 | 7.13 | 10.24 | 23.65 | 100.00 |

Average Molecular Weight = 88.71
Average Density - .718
Average Carbon Number = 6.35
H/C Ratio = 1.94

TABLE II. - Fuel composition summary - Houston [illegible]

Volume-percent Summation by Carbon Number and Compound Class

Initial

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.09 | 0.00 | 0.00 | [illegible] | 0.00 | [illegible] |
| 4 | 5.11 | 1.43 | 0.00 | [illegible] | 0.00 | [illegible] |
| 5 | 6.98 | 11.01 | 0.18 | 4.13 | 0.00 | 22.31 |
| [illegible] | 2.02 | 5.10 | 1.88 | 2.79 | 3.88 | 15.67 |
| [illegible] | [illegible] | 5.13 | 2.30 | [illegible] | [illegible] | 14.34 |
| [illegible] | [illegible] | 4.17 | 0.95 | [illegible] | [illegible] | 15.[illegible] |
| [illegible] | 0.46 | 2.71 | 0.07 | [illegible] | [illegible] | 9.50 |
| [illegible] | [illegible] | 0.43 | 0.00 | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | 0.01 | 0.00 | 0.00 | [illegible] | 1.20 |
| [illegible] | [illegible] | 0.02 | 0.00 | [illegible] | [illegible] | 0.21 |
| Total | [illegible] | [illegible] | 5.38 | 9.7[illegible] | [illegible] | 100.00 |

Average Molecular Weight = 89.95
Average Density = .730
Average Carbon Number = 6.48
[illegible]

48 Hours

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| [illegible] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| [illegible] | [illegible] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| [illegible] | [illegible] | 0.00 | 0.00 | [illegible] | 0.00 | [illegible] |
| [illegible] | [illegible] | 1.03 | 0.00 | 1.50 | 0.00 | 9.17 |
| [illegible] | 5.65 | 10.53 | 0.18 | 4.01 | 0.00 | 21.58 |
| [illegible] | [illegible] | 8.32 | 1.96 | 2.78 | 0.90 | 16.06 |
| [illegible] | [illegible] | 5.23 | 1.25 | 1.98 | 5.23 | 14.85 |
| 8 | [illegible] | 4.94 | 1.18 | 0.02 | 10.27 | 17.03 |
| 9 | [illegible] | 2.44 | 0.09 | 0.00 | 9.90 | 12.67 |
| [illegible] | 0.14 | 0.65 | 0.00 | 0.00 | 6.31 | 7.11 |
| [illegible] | 0.19 | 0.00 | 0.00 | 0.00 | 1.09 | 1.28 |
| [illegible] | [illegible] | 0.00 | 0.00 | 0.00 | 0.07 | 0.20 |
| Total | [illegible] | 33.16 | 4.66 | 10.30 | 33.78 | 100.00 |

Average Molecular Weight = 91.54
[illegible] = .736
Average Carbon Number = 6.60
[illegible]

TABLE 11. - Fuel composition summary - Wichita - winter

Volume-percent Summation by Carbon Number and Compound Class

Initial

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.12 |
| 4 | 11.92 | 1.45 | 0.00 | 2.73 | 0.00 | 16.11 |
| 5 | 6.22 | 7.29 | 0.16 | 3.92 | 0.00 | 17.59 |
| 6 | 3.56 | 7.03 | 2.06 | 3.34 | 1.21 | 17.20 |
| 7 | 1.56 | 8.90 | 1.49 | 1.28 | 5.44 | 18.66 |
| 8 | 0.56 | 9.20 | 1.10 | 0.08 | 7.29 | 18.22 |
| 9 | 0.29 | 2.45 | 0.00 | 0.00 | 5.33 | 8.07 |
| 10 | 0.15 | 0.86 | 0.00 | 0.00 | 2.76 | 3.77 |
| 11 | 0.04 | 0.00 | 0.00 | 0.00 | 0.22 | 0.26 |
| 12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total | 24.42 | 37.18 | 4.80 | 11.35 | 22.26 | 100.00 |

Average Molecular Weight = 87.02
Average Density - .710
Average Carbon Number = 6.22
H/C Ratio = 1.97

48 Hours

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 |
| 4 | 9.04 | 0.94 | 0.00 | 2.06 | 0.00 | 12.04 |
| 5 | 6.04 | 6.79 | 0.17 | 3.80 | 0.00 | 16.81 |
| 6 | 3.73 | 7.29 | 2.16 | 3.50 | 1.25 | 17.93 |
| 7 | 1.67 | 9.58 | 1.58 | 1.35 | 5.87 | 20.06 |
| 8 | 0.60 | 10.00 | 1.21 | 0.10 | 7.82 | 19.72 |
| 9 | 0.33 | 2.81 | 0.01 | 0.00 | 5.81 | 8.94 |
| 10 | 0.15 | 0.73 | 0.00 | 0.00 | 3.18 | 4.06 |
| 11 | 0.05 | 0.00 | 0.00 | 0.00 | 0.35 | 0.41 |
| 12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total | 21.65 | 38.13 | 5.12 | 10.81 | 24.28 | 100.00 |

Average Molecular Weight = 89.57
Average Density - .719
Average Carbon Number = 6.41
H/C Ratio = 1.94

TABLE 12. - Fuel composition summary - Denver - winter

Volume-percent Summation by Carbon Number and Compound Class

Initial

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.26 |
| 4 | 5.23 | 5.73 | 0.00 | 2.54 | 0.00 | 13.50 |
| 5 | 6.84 | 8.49 | 0.19 | 3.53 | 0.00 | 19.05 |
| 6 | 5.48 | 9.02 | 3.84 | 2.55 | 1.28 | 22.16 |
| 7 | 2.25 | 5.97 | 3.08 | 1.69 | 6.32 | 19.30 |
| 8 | 0.67 | 3.91 | 0.71 | 0.07 | 7.64 | 13.00 |
| 9 | 0.37 | 2.27 | 0.02 | 0.00 | 5.73 | 8.40 |
| 10 | 0.19 | 0.39 | 0.00 | 0.00 | 3.23 | 3.81 |
| 11 | 0.14 | 0.00 | 0.00 | 0.00 | 0.38 | 0.52 |
| 12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total | 21.43 | 35.78 | 7.84 | 10.38 | 24.58 | 100.00 |

Average Molecular Weight = 86.83
Average Density - .715
Average Carbon Number = 6.22
H/C Ratio - 1.94

48 Hours

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 |
| 4 | 3.87 | 3.48 | 0.00 | 1.85 | 0.00 | 9.20 |
| 5 | 6.63 | 7.88 | 0.19 | 3.39 | 0.00 | 18.10 |
| 6 | 5.79 | 9.33 | 4.05 | 2.65 | 1.35 | 23.18 |
| 7 | 2.44 | 6.90 | 2.91 | 1.80 | 6.85 | 20.89 |
| 8 | 0.76 | 4.24 | 0.82 | 0.10 | 8.37 | 14.29 |
| 9 | 0.41 | 2.52 | 0.01 | 0.00 | 6.24 | 9.17 |
| 10 | 0.21 | 0.47 | 0.00 | 0.00 | 3.66 | 4.33 |
| 11 | 0.13 | 0.00 | 0.00 | 0.00 | 0.62 | 0.75 |
| 12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total | 20.31 | 34.82 | 7.98 | 9.80 | 27.09 | 100.00 |

Average Molecular Weight = 89.57
Average Density - .726
Average Carbon Number = 6.43
H/C Ratio - 1.96

TABLE 13. - Vapor pressure versus time - summer fuels

| Fuel | Original | Equivalent Reid Vapor Pressure (psi) Time 0 | 12 | 24 | 48 |
|---|---|---|---|---|---|
| New Orleans, LA | 11.2 | 9.5 | 9.3 | 9.2 | 9.2 |
| Houston, TX | 8.8 | 8.2 | 7.6 | 7.7 | 7.4 |
| Washington, DC | 9.9 | 9.7 | 8.5 | 8.4 | 8.2 |
| Denver, CO | 9.2 | 8.9 | 8.4 | 8.5 | 8.3 |
| Ft. Lauderdale, FL | 10.6 | 9.8 | 9.5 | 9.3 | 9.3 |
| Chicago, IL | 10.2 | 9.6 | 9.5 | 9.3 | 9.3 |
| Sacramento, CA | 8.7 | 8.4 | 8.3 | 8.2 | 8.0 |
| San Diego, CA | 8.9 | 8.4 | 8.2 | 8.2 | 8.1 |
| Wichita, KS | 8.9 | 8.8 | 8.6 | 8.4 | 8.4 |
| Duluth, MN | 10.6 | 9.3 | 8.3 | 7.9 | 8.1 |

TABLE 14. - Octane ratings - summer fuels

| Fuel | RON Initial | RON Final | RON Diff. | MON Initial | MON Final | MON Diff. |
|---|---|---|---|---|---|---|
| New Orleans, LA | 95.2 | 95.1 | 0.1 | 83.7 | 83.7 | 0.0 |
| Houston, TX | 97.5 | 97.5 | 0.0 | 86.5 | 86.5 | 0.0 |
| Washington, DC | 91.7 | 91.4 | 0.3 | 81.6 | 81.6 | 0.0 |
| Denver, CO | 89.4 | 89.4 | 0.0 | 80.1 | 80.0 | 0.0 |
| Ft. Lauderdale, FL | 97.5 | 97.5 | 0.0 | 86.8 | 86.8 | 0.0 |
| Chicago, IL | 93.1 | 93.0 | 0.1 | 83.7 | 83.7 | 0.0 |
| Sacramento, CA | 98.1 | 97.5 | 0.6 | 85.8 | 85.0 | 0.8 |
| San Diego, CA | 92.7 | 92.6 | 0.1 | 82.2 | 82.2 | 0.0 |
| Wichita, KS | 94.1 | 94.0 | 0.1 | 85.0 | 84.8 | 0.2 |
| Duluth, MN | 94.9 | 94.0 | 0.0 | 86.4 | 86.1 | 0.3 |

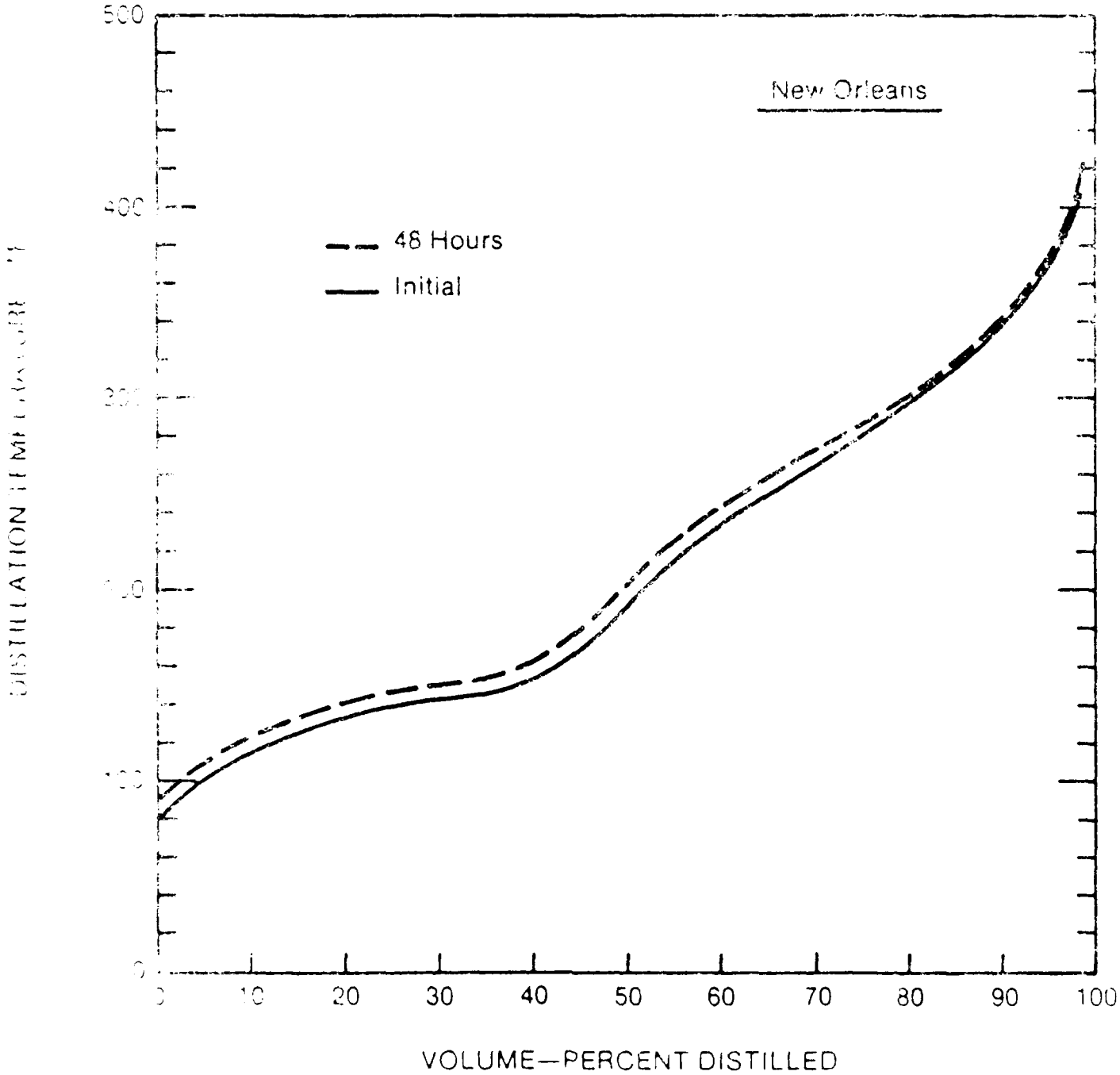


FIGURE 10. - Changes in distillation character due to weathering, summer fuel from New Orleans

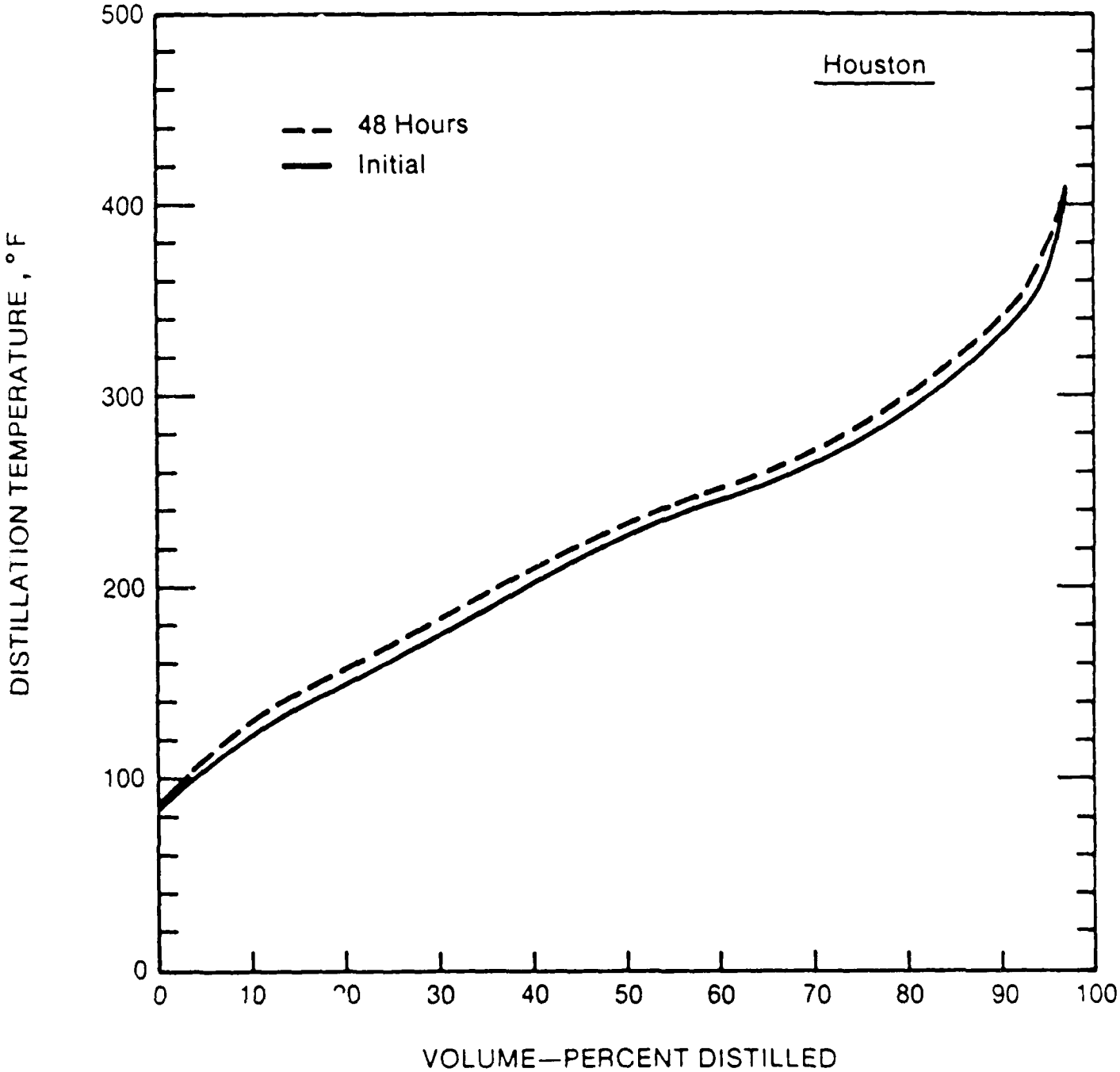


FIGURE 17. - Changes in distillation character due to weathering, summer fuels from Houston.

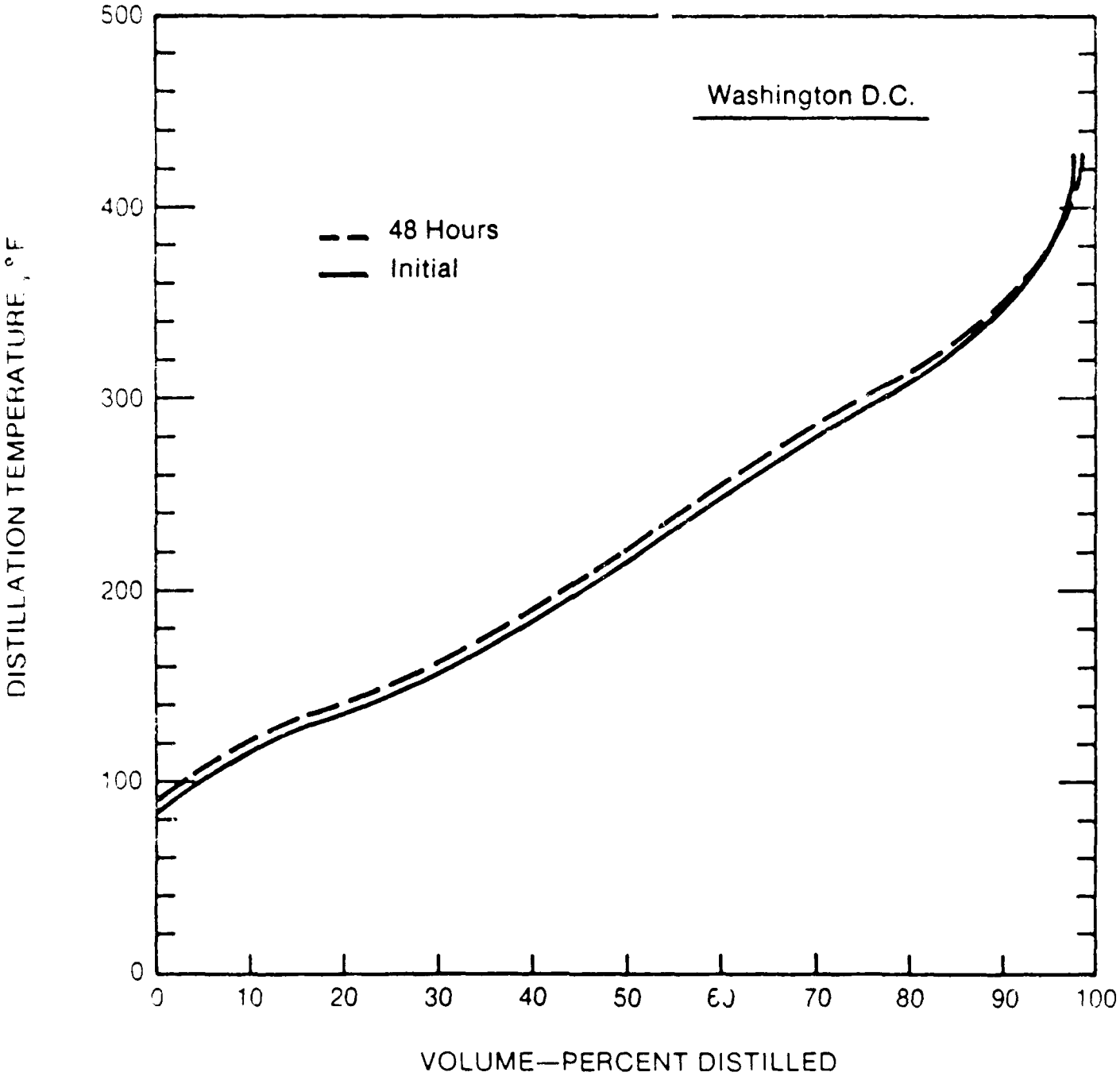


FIGURE 18. - Changes in distillation character due to weathering, summer fuels from Washington, DC

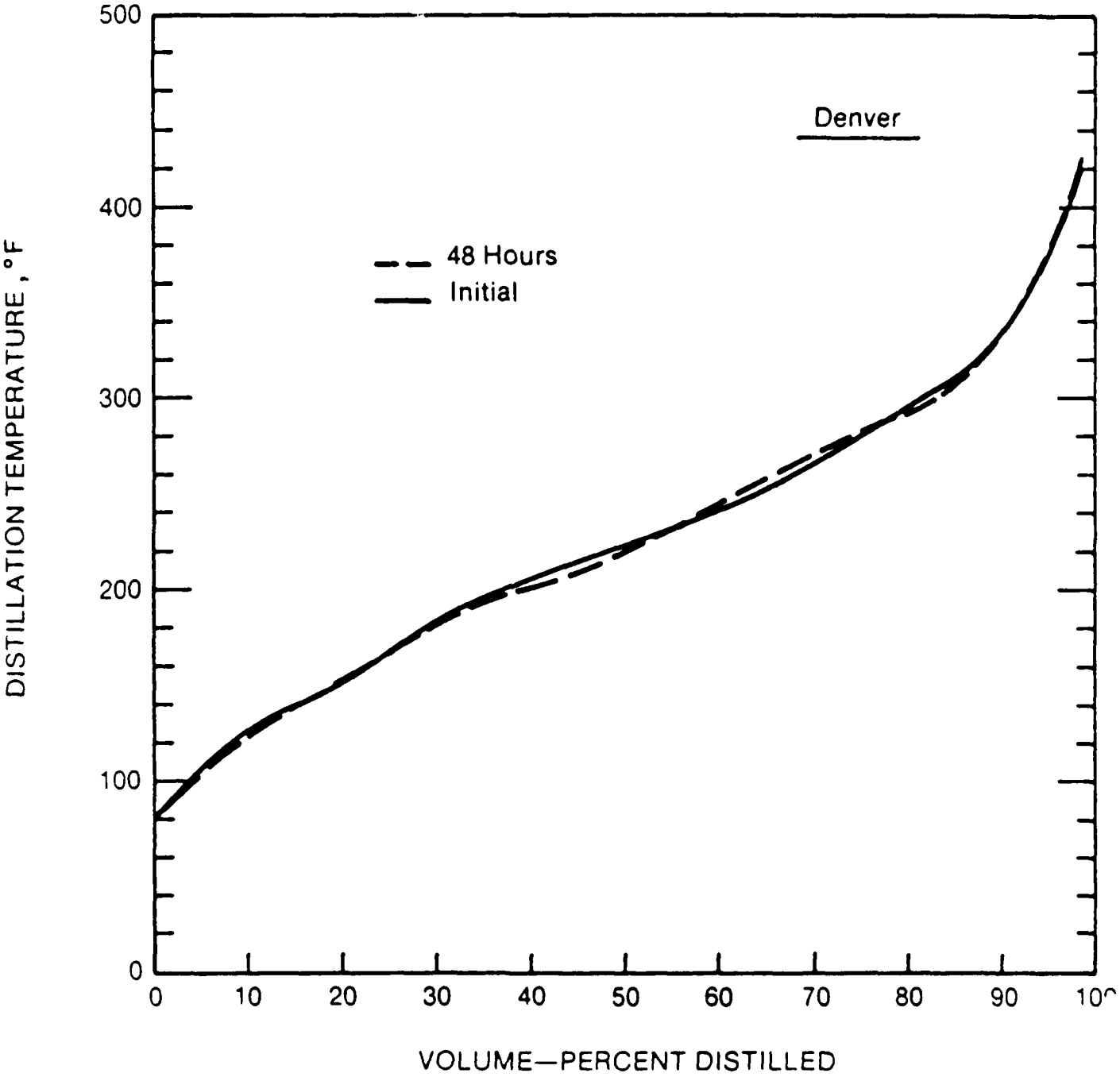


FIGURE 19. - Changes in distillation character due to weathering, summer fuel from Denver.

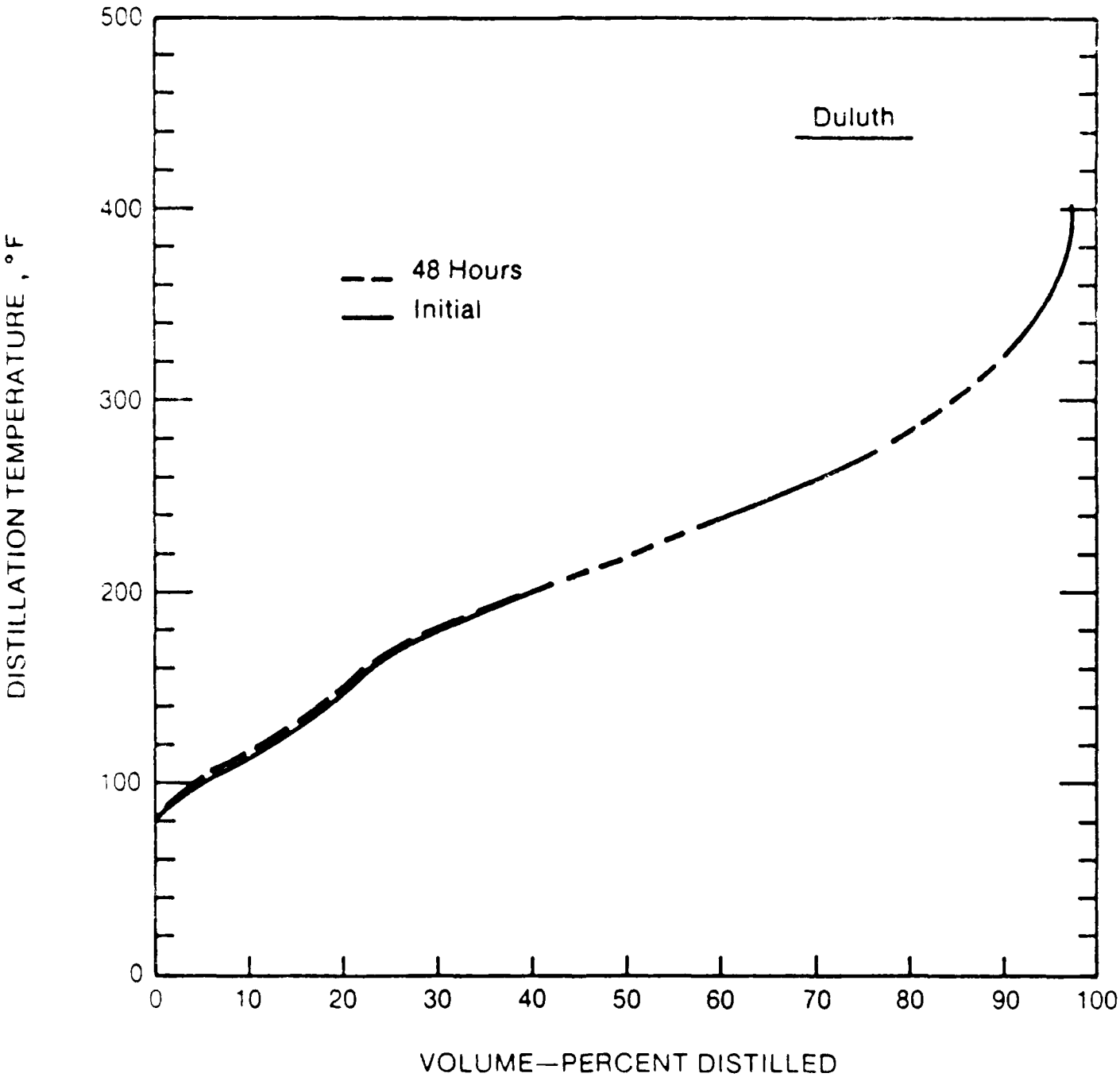


FIGURE 20. - Changes in distillation character due to weathering, summer fuel from Duluth.

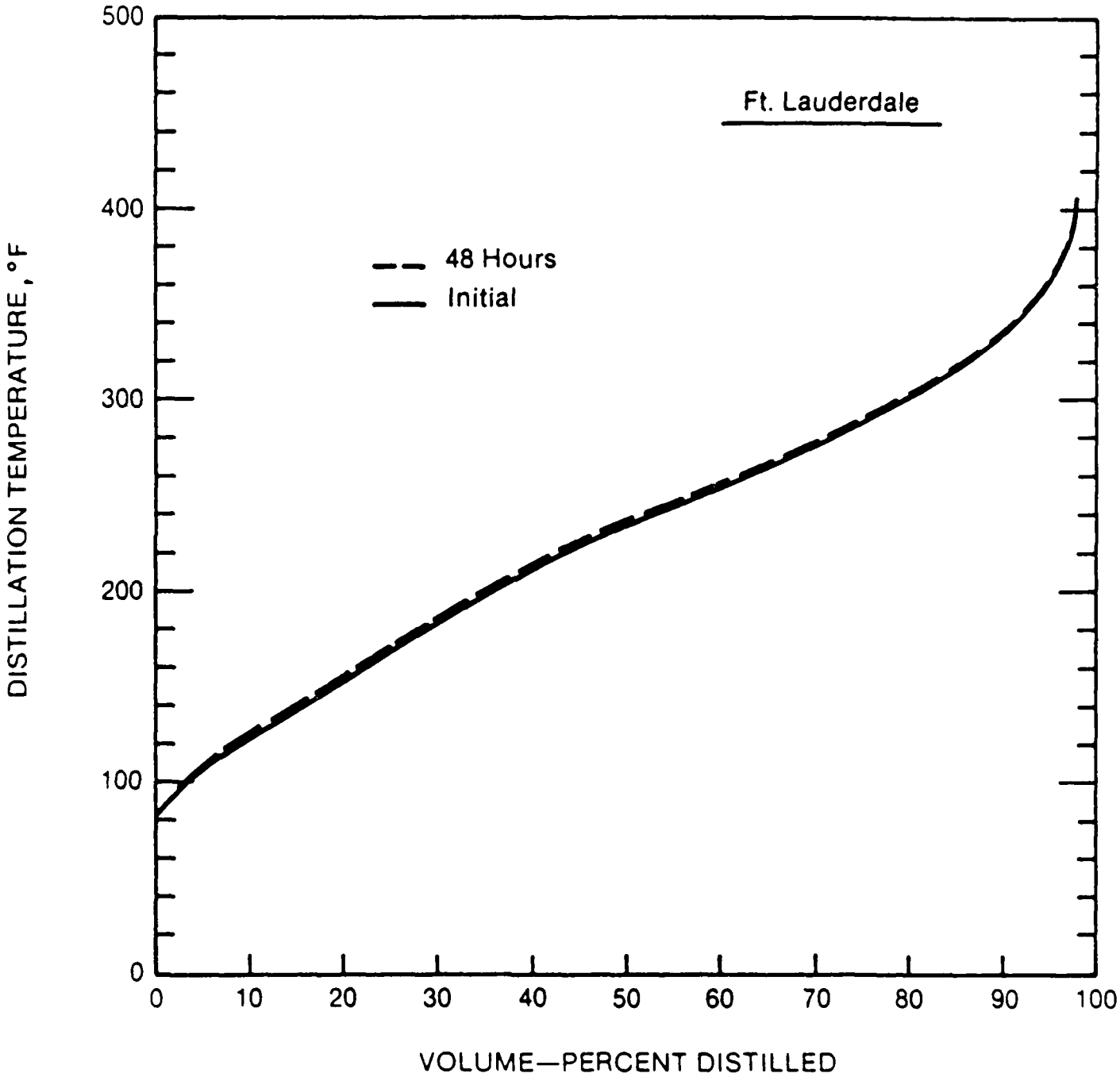


FIGURE 21. - Changes in distillation character due to weathering, summer fuel from Ft. Lauderdale.

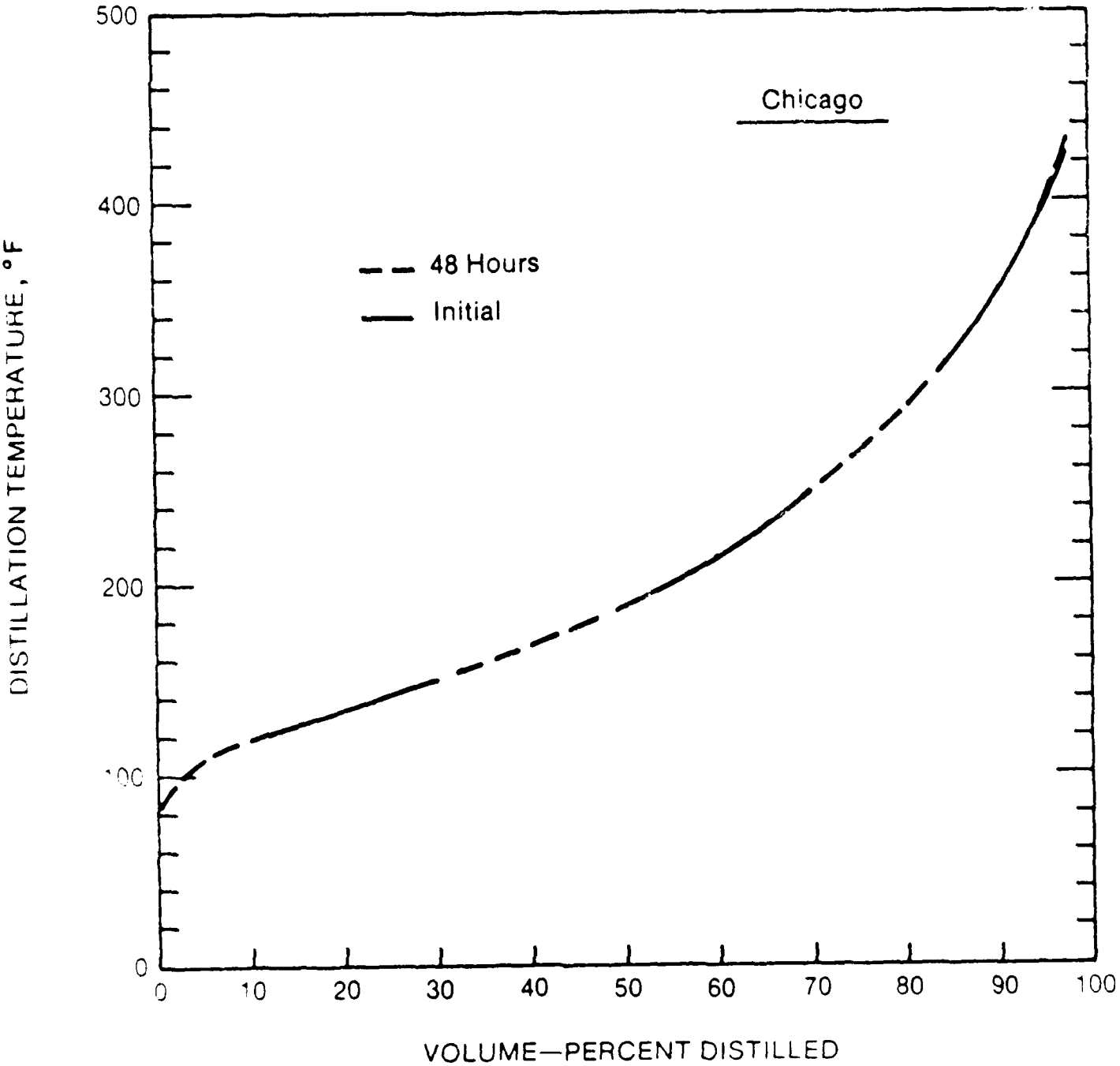


FIGURE 22. - Changes in distillation character due to weathering, summer fuel from Chicago.

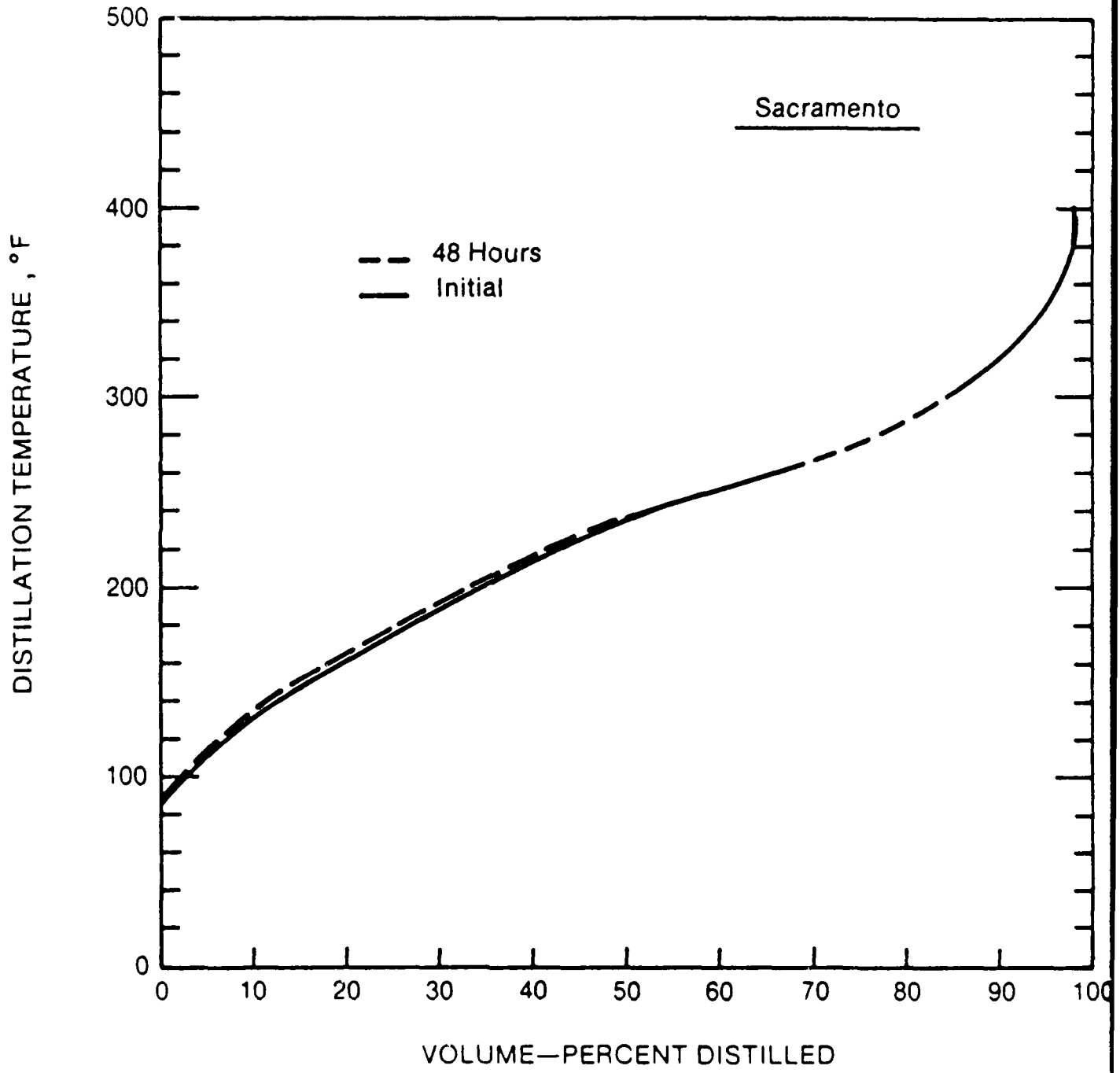


FIGURE 23. - Changes in distillation character due to weathering, summer fuel from Sacramento

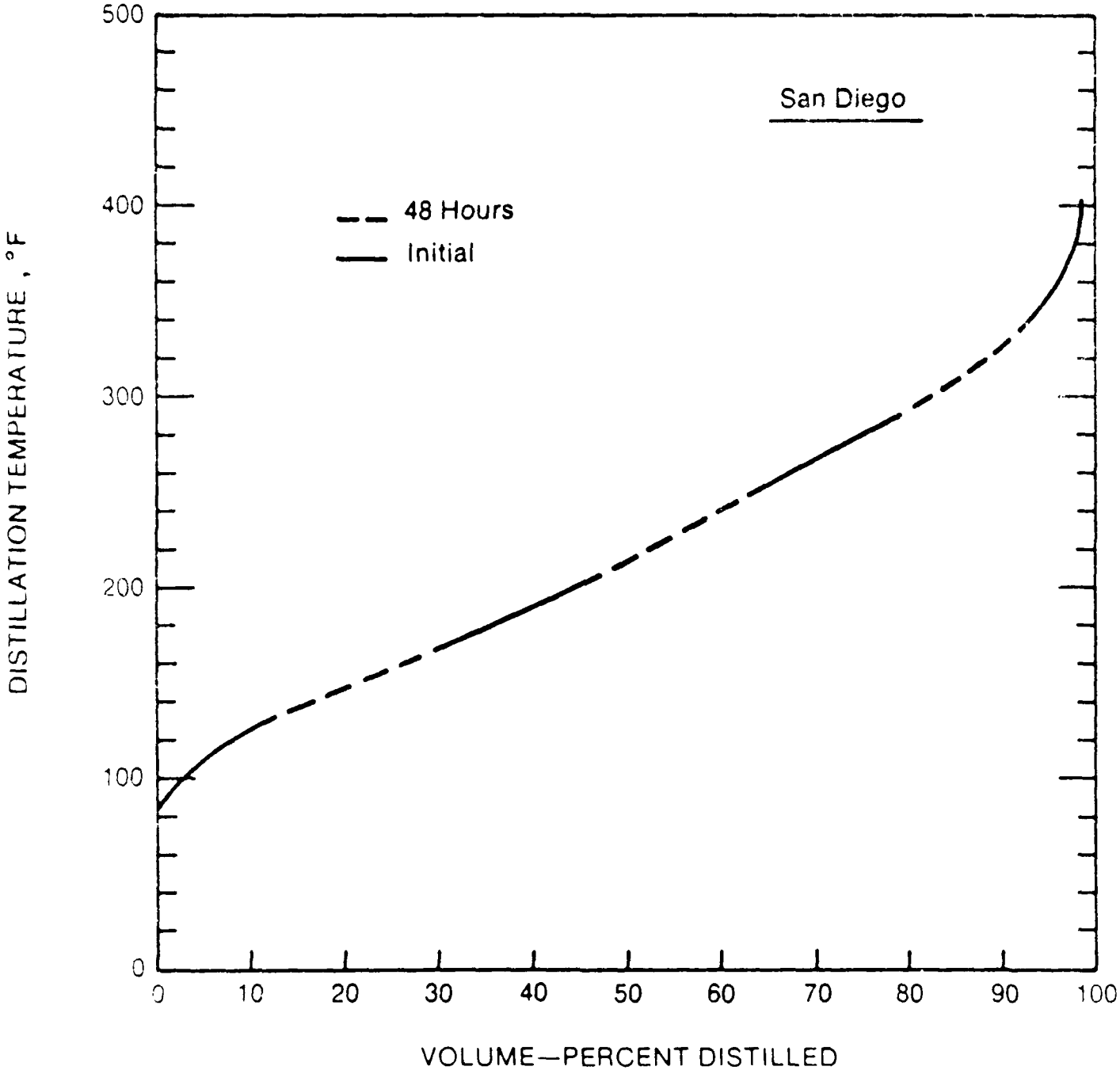


FIGURE 24. - Changes in distillation character due to weathering, summer fuel from San Diego.

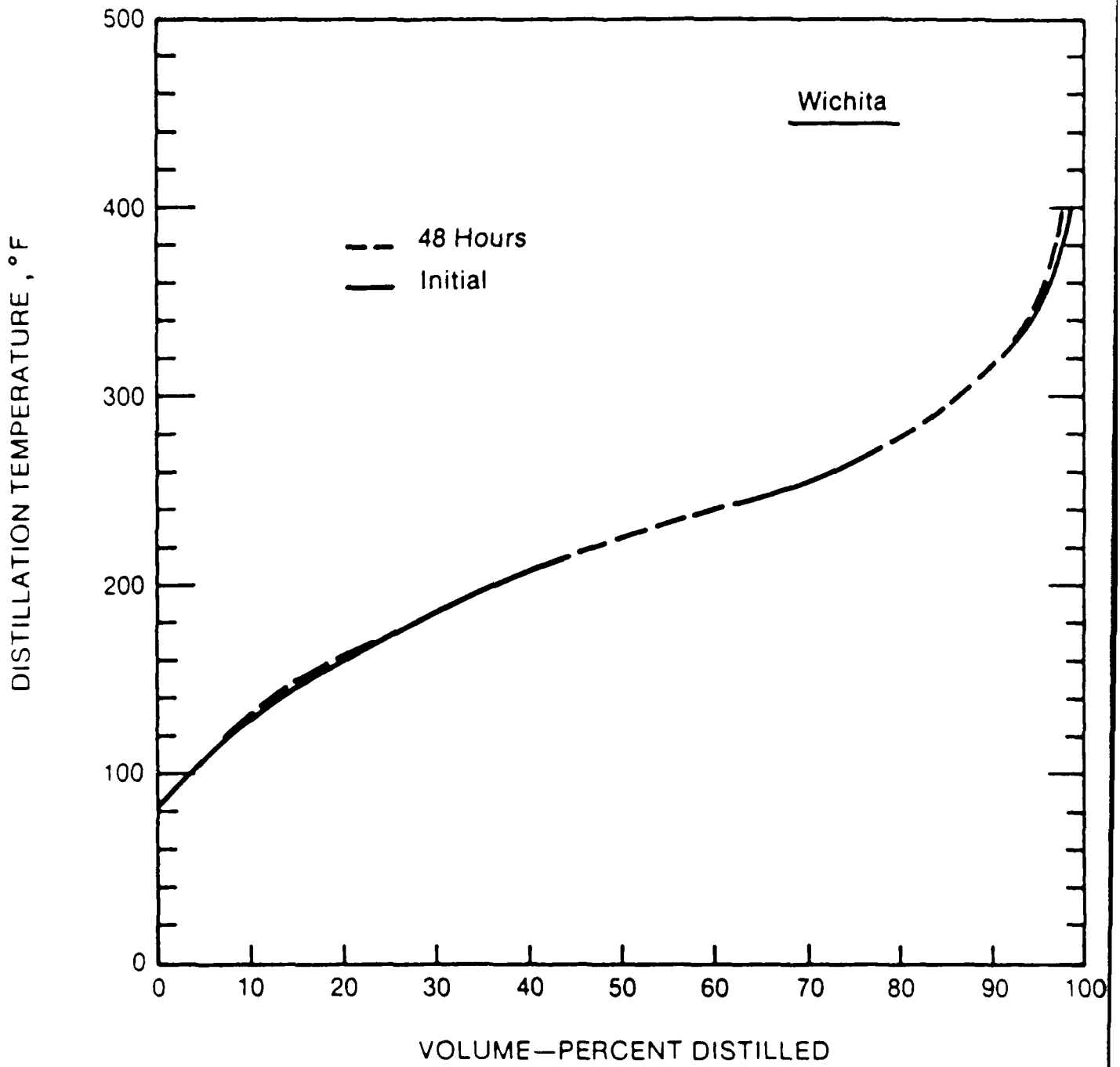


FIGURE 25. - Changes in distillation character due to weathering, summer fuel from Wichita.

TABLE 15. - Fuel composition summary - Denver - summer

Volume-percent Summation by Carbon Number and Compound Class

Initial

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.46 | 0.00 | 0.00 | 0.02 | 0.00 | 0.48 |
| 4 | 2.77 | 1.54 | 0.00 | 1.58 | 0.00 | 5.89 |
| 5 | 6.20 | 7.89 | 0.17 | 3.25 | 0.00 | 17.52 |
| 6 | 4.68 | 7.18 | 3.13 | 4.01 | 1.48 | 20.48 |
| 7 | 2.40 | 6.29 | 1.64 | 3.22 | 7.78 | 21.33 |
| 8 | 0.92 | 5.48 | 1.06 | 0.46 | 9.15 | 17.07 |
| 9 | 0.24 | 3.08 | 0.09 | 0.00 | 7.30 | 10.72 |
| 10 | 0.13 | 0.87 | 0.00 | 0.00 | 4.46 | 5.47 |
| 11 | 0.08 | 0.20 | 0.00 | 0.00 | 0.63 | 0.91 |
| 12 | 0.00 | 0.13 | 0.00 | 0.00 | 0.00 | 0.13 |
| Total | 17.89 | 32.67 | 6.10 | 12.54 | 30.80 | 100.00 |

Average Molecular Weight = 92.23
Average Density = .736
Average Carbon Number = 6.64
H/C Ratio = 1.85

48 Hours

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.24 | 0.00 | 0.00 | 0.11 | 0.00 | 0.35 |
| 4 | 8.91 | 1.94 | 0.00 | 1.11 | 0.00 | 11.96 |
| 5 | 3.90 | 5.09 | 0.12 | 2.04 | 0.00 | 11.15 |
| 6 | 3.91 | 5.89 | 2.73 | 3.26 | 1.19 | 16.97 |
| 7 | 2.34 | 6.03 | 1.62 | 3.39 | 7.92 | 21.30 |
| 8 | 1.00 | 5.53 | 1.25 | 0.38 | 10.35 | 18.52 |
| 9 | 0.27 | 3.45 | 0.09 | 0.00 | 8.57 | 12.38 |
| 10 | 0.14 | 0.93 | 0.00 | 0.00 | 5.15 | 6.23 |
| 11 | 0.09 | 0.21 | 0.00 | 0.00 | 0.71 | 1.02 |
| 12 | 0.00 | 0.13 | 0.00 | 0.00 | 0.00 | 0.13 |
| Total | 20.80 | 29.19 | 5.82 | 10.29 | 33.89 | 100.00 |

Average Molecular Weight = 92.41
Average Density = .740
Average Carbon Number = 6.19
H/C Ratio = 1.83

TABLE 16. - Fuel composition summary - Wichita - summer

Volume-percent Summation by Carbon Number and Compound Class

Initial

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.11 | 0.00 | 0.00 | 0.07 | 0.00 | 0.17 |
| 4 | 6.48 | 1.05 | 0.00 | 1.79 | 0.00 | 9.33 |
| 5 | 2.72 | 5.94 | 0.08 | 2.57 | 0.00 | 11.32 |
| 6 | 2.27 | 5.41 | 0.87 | 3.19 | 1.41 | 13.15 |
| 7 | 1.49 | 7.27 | 1.72 | 2.56 | 6.85 | 19.90 |
| 8 | 0.49 | 19.98 | 0.91 | 0.38 | 9.33 | 31.08 |
| 9 | 0.12 | 4.23 | 0.20 | 0.00 | 5.81 | 10.35 |
| 10 | 0.04 | 1.56 | 0.00 | 0.00 | 2.88 | 4.48 |
| 11 | 0.02 | 0.01 | 0.00 | 0.00 | 0.20 | 0.23 |
| 12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total | 13.75 | 45.44 | 3.77 | 10.57 | 26.48 | 100.00 |

Average Molecular Weight = 94.48
Average Density = .730
Average Carbon Number = 6.78
H/C Ratio = 1.91

48 Hours

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.08 | 0.00 | 0.00 | 0.04 | 0.00 | 0.13 |
| 4 | 7.55 | 1.21 | 0.00 | 1.57 | 0.00 | 10.33 |
| 5 | 1.41 | 3.22 | 0.05 | 1.28 | 0.00 | 5.96 |
| 6 | 2.20 | 4.15 | 0.73 | 1.99 | 1.04 | 10.12 |
| 7 | 1.49 | 6.78 | 1.53 | 2.33 | 6.92 | 19.04 |
| 8 | 0.59 | 21.42 | 1.10 | 0.34 | 11.37 | 34.83 |
| 9 | 0.16 | 5.10 | 0.25 | 0.00 | 7.81 | 13.31 |
| 10 | 0.05 | 2.24 | 0.00 | 0.00 | 3.68 | 5.97 |
| 11 | 0.03 | 0.02 | 0.00 | 0.00 | 0.27 | 0.32 |
| 12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total | 13.56 | 44.14 | 3.66 | 7.56 | 31.08 | 100.00 |

Average Molecular Weight = 97.65
Average Density = .741
Average Carbon Number = 6.62
H/C Ratio = 1.87

TABLE 17. - Fuel composition summary - Washington DC [illegible]

Volume-percent Summation by Carbon Number and Compound [illegible]

Initial

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.61 | 0.00 | 0.00 | 0.08 | 0.00 | 0.68 |
| 4 | 2.72 | 2.47 | 0.00 | 2.05 | 0.00 | 12.26 |
| 5 | 4.69 | 8.99 | 0.16 | 4.42 | 0.00 | 18.26 |
| 6 | 2.82 | 7.15 | 1.78 | 4.22 | 1.43 | 17.41 |
| 7 | 1.46 | 4.96 | 1.68 | 2.51 | 5.82 | 16.40 |
| 8 | 0.54 | 8.83 | 0.85 | 0.20 | 8.06 | 18.49 |
| 9 | 0.18 | 2.74 | 0.07 | 0.00 | [illegible] | 10.06 |
| 10 | 0.12 | 0.83 | 0.00 | 0.00 | 4.47 | 5.42 |
| 11 | 0.12 | 0.18 | 0.00 | 0.00 | 0.58 | 0.88 |
| 12 | 0.06 | 0.08 | 0.00 | 0.00 | 0.00 | 0.14 |
| Total | 13.02 | 36.23 | 4.54 | 13.49 | 27.41 | 100.00 |

Average Molecular Weight = 89.26
Average Density = .722
Average Carbon Number = 6.15
H/C Ratio = 1.90

48 Hours

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| [illegible] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| [illegible] | 0.57 | 0.00 | 0.00 | 0.05 | 0.00 | 0.61 |
| [illegible] | 2.36 | 2.34 | 0.00 | 1.89 | 0.00 | 11.59 |
| [illegible] | 4.64 | 8.87 | 0.16 | 4.37 | 0.00 | 18.04 |
| [illegible] | 2.81 | 7.19 | 1.78 | 4.27 | 1.43 | 17.53 |
| [illegible] | 1.47 | 5.01 | 1.69 | 2.52 | 5.90 | 16.60 |
| [illegible] | 0.55 | 8.35 | 0.90 | 0.21 | 8.24 | 18.88 |
| [illegible] | 0.12 | 2.81 | 0.08 | 0.00 | 7.24 | 10.32 |
| [illegible] | 0.10 | 0.90 | 0.00 | 0.00 | 4.40 | 5.41 |
| [illegible] | 0.13 | 0.13 | 0.00 | 0.00 | 0.55 | 0.86 |
| [illegible] | 0.07 | 0.08 | 0.00 | 0.00 | 0.00 | 0.15 |
| [illegible] | [illegible] | 36.34 | 4.61 | 13.30 | 27.75 | 100.00 |

[illegible] Weight = 89.76
[illegible]
[illegible] Number = 6.00

TABLE 18. - Fuel composition summary - San Diego - summer

Volume-percent Summation by Carbon Number and Compound Class

Initial

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.28 | 0.00 | 0.00 | 0.08 | 0.00 | 0.36 |
| 4 | 15.37 | 2.61 | 0.00 | 3.61 | 0.00 | 21.59 |
| 5 | 3.67 | 10.72 | 0.13 | 3.34 | 0.00 | 17.85 |
| 6 | 2.37 | 7.80 | 2.98 | 3.81 | 1.28 | 18.25 |
| 7 | 1.15 | 4.79 | 1.87 | 2.45 | 5.67 | 15.93 |
| 8 | 0.43 | 3.71 | 0.99 | 0.09 | 8.06 | 13.28 |
| 9 | 0.12 | 2.02 | 0.05 | 0.00 | 6.36 | 8.55 |
| 10 | 0.06 | 0.19 | 0.00 | 0.00 | 3.28 | 3.53 |
| 11 | 0.00 | 0.02 | 0.00 | 0.00 | 0.18 | 0.20 |
| 12 | 0.00 | 0.48 | 0.00 | 0.00 | 0.00 | 0.48 |
| Total | 23.47 | 32.32 | 6.02 | 13.37 | 24.82 | 100.00 |

Average Molecular Weight = 83.84
Average Density = .707
Average Carbon Number = 5.13
H/C Ratio = 1.94

48 Hours

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.15 | 0.00 | 0.00 | 0.05 | 0.00 | 0.20 |
| 4 | 7.15 | 1.30 | 0.00 | 2.09 | 0.00 | 10.54 |
| 5 | 2.97 | 11.39 | 0.15 | 4.62 | 0.00 | 19.13 |
| 6 | 2.32 | 8.63 | 3.36 | 4.53 | 1.48 | 20.32 |
| 7 | 1.30 | 5.55 | 2.13 | 2.79 | 6.43 | 18.20 |
| 8 | 0.53 | 4.33 | 1.38 | 0.21 | 9.23 | 15.67 |
| 9 | 0.14 | 2.35 | 0.08 | 0.00 | 7.44 | 10.02 |
| 10 | 0.08 | 0.50 | 0.00 | 0.00 | 4.20 | 4.78 |
| 11 | 0.06 | 0.16 | 0.00 | 0.00 | 0.65 | 0.87 |
| 12 | 0.00 | 0.23 | 0.00 | 0.00 | 0.05 | 0.28 |
| Total | 14.71 | 34.43 | 7.09 | 14.28 | 29.49 | 100.00 |

Average Molecular Weight = 89.32
Average Density = .729
Average Carbon Number = 6.08
H/C Ratio = 1.87

TABLE 19. - Fuel composition summary - [illegible]

Volume-percent Summation by Carbon Number and [illegible]

Initial

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| [illegible] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| [illegible] | 0.00 | 0.00 | 0.00 | 0.05 | 0.00 | 0.10 |
| [illegible] | 5.57 | 0.88 | 0.00 | 2.36 | 0.00 | 8.91 |
| [illegible] | 3.01 | 7.93 | 0.11 | 4.64 | 0.00 | 15.69 |
| [illegible] | 1.89 | 5.61 | 1.31 | 2.85 | 1.20 | 12.86 |
| [illegible] | 1.06 | 4.29 | 0.91 | 1.47 | 9.58 | 17.[illegible] |
| [illegible] | 0.35 | 15.41 | 0.44 | 0.10 | 12.24 | 28.53 |
| [illegible] | [illegible] | 1.95 | 0.00 | 0.00 | 8.56 | 11.12 |
| [illegible] | 1.36 | 0.22 | 0.00 | 0.00 | 2.39 | 4.39 |
| [illegible] | 0.02 | 0.00 | 0.00 | 0.00 | 0.61 | 0.63 |
| [illegible] | [illegible] | 0.31 | 0.00 | 0.00 | 0.00 | 0.31 |
| Total | [illegible] | 36.59 | 2.75 | 11.45 | 35.81 | 100.00 |

Average Molecular Weight = 93.15
[illegible] = 747
Average Carbon Number = 6.74
[illegible] = 1.79

48 Hours

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| [illegible] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| [illegible] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| [illegible] | 0.52 | 0.00 | 0.00 | 0.04 | 0.00 | 0.57 |
| [illegible] | [illegible] | 2.36 | 0.00 | 2.19 | 0.00 | 12.50 |
| [illegible] | [illegible] | 7.33 | 0.10 | 4.49 | 0.00 | 14.73 |
| [illegible] | [illegible] | 5.30 | 1.43 | 2.77 | 1.14 | 12.42 |
| [illegible] | [illegible] | 4.14 | 1.05 | 1.17 | 9.27 | 16.68 |
| [illegible] | [illegible] | 14.63 | 0.45 | 0.02 | 11.99 | 27.44 |
| [illegible] | 0.20 | 1.88 | 0.00 | 0.00 | 8.54 | 10.62 |
| [illegible] | 0.08 | 0.14 | 0.00 | 0.00 | 4.04 | 4.26 |
| [illegible] | 0.00 | 0.00 | 0.00 | 0.00 | 0.45 | 0.45 |
| [illegible] | 0.00 | 0.33 | 0.00 | 0.00 | 0.00 | 0.33 |
| [illegible] | [illegible] | 36.12 | 3.03 | 10.68 | 35.43 | 100.00 |

[illegible] Molecular Weight = 91.07
[illegible] = 740
[illegible] Carbon Number = 6.32
[illegible] = 1.31

TABLE 20. - Fuel composition summary - Sacramento - summer

Volume-percent Summation by Carbon Number and Compound Class

Initial

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.27 | 0.00 | 0.00 | 0.08 | 0.00 | 0.35 |
| 4 | 8.72 | 1.88 | 0.00 | 1.08 | 0.00 | 11.68 |
| 5 | 1.70 | 4.80 | 0.09 | 2.04 | 0.00 | 8.63 |
| 6 | 2.20 | 5.63 | 1.21 | 2.97 | 2.84 | 14.85 |
| 7 | 1.57 | 5.02 | 0.92 | 1.87 | 12.68 | 22.06 |
| 8 | 0.57 | 5.43 | 0.38 | 0.11 | 17.06 | 23.54 |
| 9 | 0.23 | 1.44 | 0.00 | 0.00 | 11.73 | 13.40 |
| 10 | 0.09 | 0.18 | 0.00 | 0.00 | 4.66 | 4.92 |
| 11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.55 | 0.55 |
| 12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total | 15.35 | 24.37 | 2.60 | 8.16 | 49.52 | 100.00 |

Average Molecular Weight = 93.00
Average Density = .766
Average Carbon Number = 6.34
H/C Ratio = 1.67

48 Hours

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.24 | 0.00 | 0.00 | 0.10 | 0.00 | 0.33 |
| 4 | 8.68 | 1.82 | 0.00 | 1.06 | 0.00 | 11.56 |
| 5 | 1.71 | 4.71 | 0.09 | 2.07 | 0.00 | 8.57 |
| 6 | 2.16 | 5.65 | 1.23 | 3.05 | 2.92 | 15.02 |
| 7 | 1.57 | 5.04 | 0.93 | 1.88 | 12.80 | 22.22 |
| 8 | 0.57 | 5.45 | 0.38 | 0.11 | 16.94 | 23.45 |
| 9 | 0.23 | 1.35 | 0.00 | 0.00 | 11.72 | 13.30 |
| 10 | 0.09 | 0.13 | 0.00 | 0.00 | 4.71 | 4.93 |
| 11 | 0.00 | 0.05 | 0.00 | 0.00 | 0.56 | 0.62 |
| 12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total | 15.24 | 24.21 | 2.63 | 8.27 | 49.65 | 100.00 |

Average Molecular Weight = 93.04
Average Density = .766
Average Carbon Number = 6.34
H/C Ratio = 1.66

TABLE 21. - Fuel composition summary - Fort Lauderdale - summer

Volume-percent Summation by Carbon Number and Compound Class

Initial

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.50 | 0.00 | 0.00 | 0.07 | 0.00 | 0.57 |
| 4 | 7.85 | 2.58 | 0.00 | 1.67 | 0.00 | 12.10 |
| 5 | 5.38 | 7.40 | 0.16 | 3.28 | 0.00 | 16.22 |
| 6 | 1.26 | 4.03 | 0.63 | 1.82 | 0.93 | 8.67 |
| 7 | 1.12 | 3.77 | 0.88 | 0.99 | 11.09 | 17.85 |
| 8 | 0.55 | 14.80 | 0.24 | 0.10 | 11.52 | 27.22 |
| 9 | 0.18 | 1.41 | 0.00 | 0.00 | 8.90 | 10.49 |
| 10 | 0.08 | 0.47 | 0.00 | 0.00 | 5.04 | 5.59 |
| 11 | 0.00 | 0.46 | 0.00 | 0.00 | 0.62 | 1.08 |
| 12 | 0.00 | 0.22 | 0.00 | 0.00 | 0.00 | 0.22 |
| Total | 16.93 | 35.12 | 1.92 | 7.94 | 38.10 | 100.00 |

Average Molecular Weight = 91.95
Average Density = .743
Average Carbon Number = 6.42
H/C Ratio = 1.79

48 Hours

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.12 | 0.00 | 0.00 | 0.08 | 0.00 | 0.20 |
| 4 | 8.25 | 1.42 | 0.00 | 0.68 | 0.00 | 10.35 |
| 5 | 2.79 | 3.91 | 0.10 | 2.12 | 0.00 | 8.92 |
| 6 | 1.07 | 3.15 | 0.60 | 2.16 | 0.77 | 7.75 |
| 7 | 1.19 | 3.34 | 0.59 | 0.72 | 12.13 | 17.98 |
| 8 | 0.67 | 16.82 | 0.31 | 0.11 | 14.33 | 32.24 |
| 9 | 0.24 | 1.76 | 0.00 | 0.00 | 11.64 | 13.64 |
| 10 | 0.10 | 0.61 | 0.00 | 0.00 | 6.60 | 7.30 |
| 11 | 0.01 | 0.65 | 0.00 | 0.00 | 0.80 | 1.47 |
| 12 | 0.00 | 0.17 | 0.00 | 0.00 | 0.00 | 0.17 |
| Total | 14.43 | 31.83 | 1.60 | 5.88 | 46.26 | 100.00 |

Average Molecular Weight = 97.01
Average Density = .76
Average Carbon Number = 6.64

TABLE 22. - Fuel composition summary - Duluth - summer

Volume-percent Summation by Carbon Number and Compound Class

Initial

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.63 | 0.00 | 0.00 | 0.04 | 0.00 | 0.67 |
| 4 | 9.86 | 3.71 | 0.00 | 2.19 | 0.00 | 15.76 |
| 5 | 2.60 | 5.94 | 0.05 | 1.34 | 0.00 | 9.94 |
| 6 | 2.27 | 5.81 | 0.88 | 2.09 | 2.20 | 13.24 |
| 7 | 1.29 | 6.79 | 1.44 | 1.66 | 8.09 | 19.28 |
| 8 | 0.41 | 18.28 | 0.25 | 0.06 | 9.04 | 28.06 |
| 9 | 0.09 | 1.68 | 0.00 | 0.00 | 6.17 | 7.95 |
| 10 | 0.04 | 1.00 | 0.00 | 0.00 | 3.61 | 4.65 |
| 11 | 0.02 | 0.19 | 0.00 | 0.00 | 0.25 | 0.47 |
| 12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total | 17.21 | 43.40 | 2.63 | 7.39 | 29.36 | 100.00 |

Average Molecular Weight = 90.48
Average Density = .725
Average Carbon Number = 6.24
H/C Ratio = 1.89

48 Hours

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.08 | 0.00 | 0.00 | 0.04 | 0.00 | 0.12 |
| 4 | 7.07 | 1.32 | 0.00 | 1.24 | 0.00 | 9.63 |
| 5 | 1.28 | 2.95 | 0.04 | 0.69 | 0.00 | 4.95 |
| 6 | 2.03 | 4.51 | 0.81 | 1.52 | 1.68 | 10.56 |
| 7 | 1.44 | 7.14 | 1.43 | 1.68 | 8.98 | 20.68 |
| 8 | 0.56 | 21.29 | 0.36 | 0.07 | 12.14 | 34.41 |
| 9 | 0.14 | 2.34 | 0.00 | 0.00 | 9.14 | 11.61 |
| 10 | 0.06 | 1.56 | 0.00 | 0.00 | 5.44 | 7.06 |
| 11 | 0.04 | 0.09 | 0.00 | 0.00 | 0.77 | 0.90 |
| 12 | 0.00 | 0.08 | 0.00 | 0.00 | 0.00 | 0.08 |
| Total | 12.69 | 41.28 | 2.64 | 5.25 | 38.15 | 100.00 |

Average Molecular Weight = 98.22
Average Density = .754
Average Carbon Number = 6.73
H/C Ratio = 1.79

TABLE 23. - Fuel composition summary - New Orleans - summer

Volume-percent Summation by Carbon Number and Compound Class

Initial

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.59 | 0.00 | 0.00 | 0.10 | 0.00 | 0.69 |
| 4 | 8.74 | 3.65 | 0.00 | 2.10 | 0.00 | 14.49 |
| 5 | 5.23 | 6.29 | 0.14 | 2.70 | 0.00 | 14.36 |
| 6 | 4.24 | 6.43 | 2.24 | 3.63 | 1.71 | 18.25 |
| 7 | 1.61 | 5.27 | 1.25 | 2.14 | 7.21 | 17.48 |
| 8 | 0.54 | 5.19 | 0.81 | 0.15 | 10.29 | 16.98 |
| 9 | 0.16 | 2.51 | 0.08 | 0.00 | 8.30 | 11.05 |
| 10 | 0.08 | 0.63 | 0.00 | 0.00 | 4.82 | 5.53 |
| 11 | 0.05 | 0.19 | 0.00 | 0.00 | 0.68 | 0.92 |
| 12 | 0.00 | 0.20 | 0.00 | 0.00 | 0.04 | 0.24 |
| Total | 21.24 | 30.37 | 4.51 | 10.83 | 33.06 | 100.00 |

Average Molecular Weight = 89.21
Average Density = .731
Average Carbon Number = 6.16
H/C Ratio = 1.84

48 Hours

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.54 | 0.00 | 0.00 | 0.08 | 0.00 | 0.63 |
| 4 | 6.91 | 3.15 | 0.00 | 2.15 | 0.00 | 12.21 |
| 5 | 5.37 | 5.93 | 0.14 | 2.72 | 0.00 | 14.16 |
| 6 | 4.29 | 6.48 | 2.27 | 3.64 | 1.74 | 18.42 |
| 7 | 1.66 | 5.40 | 1.40 | 2.15 | 7.50 | 18.11 |
| 8 | 0.37 | 5.26 | 0.85 | 0.15 | 10.75 | 17.58 |
| 9 | 0.16 | 2.74 | 0.08 | 0.00 | 8.64 | 11.62 |
| 10 | 0.28 | 0.55 | 0.00 | 0.00 | 5.30 | 6.13 |
| 11 | 0.05 | 0.19 | 0.00 | 0.00 | 0.67 | 0.91 |
| 12 | 0.00 | 0.19 | 0.00 | 0.00 | 0.04 | 0.23 |
| Total | 19.84 | 29.90 | 4.74 | 10.89 | 34.63 | 100.00 |

Average Molecular Weight = 90.64
Average Density = .737
Average Carbon Number = 6.27
H/C Ratio = 1.82

TABLE 24. - Fuel composition summary - Chicago - summer

Volume-percent Summation by Carbon Number and Compound Class

Initial

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.67 | 0.00 | 0.00 | 0.04 | 0.00 | 0.71 |
| 4 | 6.30 | 2.57 | 0.00 | 1.93 | 0.00 | 10.80 |
| 5 | 5.94 | 10.82 | 0.21 | 6.56 | 0.00 | 23.53 |
| 6 | 3.78 | 10.04 | 2.95 | 5.22 | 1.99 | 23.98 |
| 7 | 1.64 | 4.40 | 1.55 | 2.53 | 8.10 | 18.22 |
| 8 | 0.66 | 3.86 | 0.71 | 0.18 | 4.79 | 10.19 |
| 9 | 0.09 | 1.75 | 0.06 | 0.00 | 5.02 | 6.93 |
| 10 | 0.09 | 0.30 | 0.00 | 0.00 | 3.80 | 4.20 |
| 11 | 0.16 | 0.16 | 0.00 | 0.00 | 0.67 | 0.99 |
| 12 | 0.13 | 0.26 | 0.00 | 0.00 | 0.04 | 0.44 |
| Total | 19.47 | 34.16 | 5.49 | 16.46 | 24.42 | 100.00 |

Average Molecular Weight = 85.82
Average Density = .716
Average Carbon Number = 5.91
H/C Ratio = 1.91

48 Hours

| Carbon No. | Paraffins Normal | Paraffins Iso | Naphthenes | Olefins | Aromatics | Total |
|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.09 | 0.00 | 0.00 | 0.05 | 0.00 | 0.15 |
| 4 | 6.98 | 1.17 | 0.00 | 1.63 | 0.00 | 9.79 |
| 5 | 2.34 | 4.55 | 0.12 | 3.17 | 0.00 | 10.18 |
| 6 | 2.98 | 7.39 | 2.44 | 3.73 | 1.48 | 18.03 |
| 7 | 1.95 | 4.94 | 1.86 | 3.27 | 10.42 | 22.44 |
| 8 | 1.00 | 6.02 | 1.32 | 0.25 | 8.31 | 16.90 |
| 9 | 0.16 | 2.99 | 0.11 | 0.00 | 9.00 | 12.26 |
| 10 | 0.17 | 0.81 | 0.00 | 0.00 | 6.51 | 7.49 |
| 11 | 0.29 | 0.31 | 0.00 | 0.00 | 1.04 | 1.63 |
| 12 | 0.24 | 0.79 | 0.00 | 0.00 | 0.11 | 1.14 |
| Total | 16.20 | 28.98 | 5.85 | 12.10 | 36.87 | 100.00 |

Average Molecular Weight = 94.21
Average Density = .752
Average Carbon Number = 6.39
H/C Ratio = 1.78

## APPENDIX A

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