

covered for some time. It would be unreasonable to expect uniform results with such wide variations existent. The arrangement of the tubes in the furnace and the numbers given to them in operation are shown in figure 39.

Frequently two tubes occupying the same relative position in the furnace, such as, for example, tubes 3 and 8, gave widely varying results, the specific gravities of the recovered oil ranging in some cases from 0.88 to 1.00. The wide differences in character of the results obtained will be more clearly perceived on examination of the data contained in Table 56, which represents the results of a study of the reactions in the individual tubes, extending over a period of some weeks.

TABLE 56.—Variations in specific gravity of oils recovered from individual tubes in a 10-tube furnace (tubes 8 inches in diameter and 14 feet long).^a

Run No.	Specific gravity in tube No.—									
	1	2	3	4	5	6	7	8	9	10
1	0.91	0.98	0.91	0.94	0.89	-----	1.00	0.99	0.96	0.92
2	.90	.97	.91	.93	.98	-----	-----	.95	1.00	.98
3	.92	.94	.96	.96	.92	0.90	.99	.92	.95	.93
4	.92	.96	.99	.92	1.01	.92	.97	.94	.99	.97
5	.94	.94	.90	.94	.94	.94	.98	.95	1.01	.99
6	.93	.98	.99	1.00	.91	.97	1.00	.96	1.01	.96
7	.91	.91	.88	1.00	.89	.96	.92	.91	.97	-----
8	.94	.89	.96	.87	.93	.95	.87	.91	.98	-----
9	.94	.99	.92	.95	1.00	.98	.88	.94	.97	-----
10	.93	.87	.89	.98	.97	.92	.90	.97	.96	.92
11	.93	.89	.93	.93	.95	.88	.94	.90	1.05	.98
12	.87	.90	.92	.93	.93	.90	.94	.92	.93	.89
13	.92	.90	.96	1.00	.99	.93	.94	.91	.88	.93
14	.96	.89	.96	.99	1.10	.92	.99	.89	.95	.92
15	.96	.98	.96	.98	1.02	.96	.93	.90	.93	.94
16	.93	.88	.90	1.06	.91	.90	.84	.98	1.04	.93
17	.90	.89	.87	.94	.96	.90	.98	.92	.98	.97
18	.95	.91	.89	.88	.95	.85	.89	.95	.99	.96
19	.92	.97	.88	.89	.89	.95	.98	.91	.99	.95
20	.92	.95	.89	.93	.95	.94	.93	.94	1.00	.95
21	.90	.94	.86	.96	.92	.94	.91	1.00	.95	.91
22	1.00	1.01	.95	.97	.91	.98	.97	.99	.99	.95
23	.94	.98	.90	.95	.94	.97	.98	1.01	.99	.94
24	.91	.94	.87	.98	.90	.94	.94	.97	.96	.94
25	.91	.92	.87	.94	.91	.93	.95	.96	.93	.91
26	.98	.99	.97	.99	.97	.96	.97	1.01	1.01	.93
27	1.00	1.02	.92	.95	1.00	.94	.95	1.05	1.05	.96
28	.91	.92	.87	.94	.91	.91	.93	.96	.93	.91
29	.98	.99	.97	.99	.99	.97	.96	1.01	1.01	.95
30	1.00	1.02	.92	.95	.95	1.00	.94	1.05	1.05	.98

^a Compare with results presented in Table 58.

On account of the fact that the principal commercial development of the benzene-toluene process has been in connection with these 10-tube furnaces considerable space has been given in a subsequent part of this report to a description of the mechanical features connected with this type of installation.

RESULTS LOW BECAUSE OF INADEQUATE CONDENSATION.

In considering the percentage yields reported, too much emphasis can not be placed upon the fact that adequate condensation has not been afforded and that on this account the results are less favorable than would be obtained normally.

It is the custom among oil refiners to allow 1½ to 2 square feet of condensing surface per barrel of oil treated in a given retort. On this basis the area of condensing surface for the individual tubes was insufficient and has been detrimental to the products obtained, as is evident from the following facts:

Benzene boils at a temperature of 80° C. and toluene at 110° C. At 30° C. the vapor pressure of benzene is one-fourth atmosphere, at 60° C. it is one-half atmosphere, and at 120° C. it is three atmospheres. The same relative order of temperature and pressure values holds for toluene.

In testing the temperature of recovered oil as it left the condenser figures for an average of six runs ranged between 88° and 125° C. In other words, the liquid left the condenser at a temperature higher than the boiling points of the products sought. This was possible owing to the presence of quantities of higher-boiling constituents which tended to retain a part of the lower-boiling constituents.

Separate condensers were installed, as previously mentioned, in order to collect the liquid products of the gaseous reaction in each individual tube. It has been the practice to tap these condensers and to collect and measure the product in a bucket, the total product from each tube being kept separate from the products of the other tubes. This was done primarily for the purpose of studying the furnace conditions with respect to the individual tubes, and provision was made from the outset for ultimately connecting each primary and secondary condenser allotted to each tube into a common header. It was felt inadvisable to do so as long as the wide variations existed which are shown in Table 56.

The recovered products taken from the condenser at this high temperature evaporated when exposed to the air. Fully 50 per cent of the benzene and toluene were dissipated in this way. This serious loss renders all the reported yields proportionately low. There is absolutely no question in the mind of the authors, or of those in connection with the development operations, but that the yields thus far obtained could have been approximately doubled had adequate condensation been had from the outset.

The inadequacy of the condensing apparatus may be better realized when it is stated that the area of condensing surface per tube was approximately 10 square feet, and the volume of gases per hour passing through the condenser was 1,500 cubic feet. In other words 1 square foot of condensing surface was available for each 150 cubic feet of gas generated per hour.

The foregoing is not intended as a criticism of the operating methods followed, as it was absolutely essential that opportunity be afforded to analyze the products from each tube, which could not have been done in any other manner. It should be borne in mind