Report 1 — Inspection of the Plant

Date of Inspection: April 6, 7 and 8, 1945

Personnel of Inspection Team:

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General.

The information gained from the mere visual inspection of the plant at Sterkrade-Holten was very slight and in part was rather confusing. This was true to a greater extent than any other target visited and was due to three reasons :

1. Key personnel familiar with the plant was not present, nor could they be readily located at the time. The few employees there at the time of the visit of the investigating team had only a hazy knowledge of plant operations as a whole, although each one had some knowledge of a specific operation or research project.

2. Pertinent documents, including process flow diagrams and research reports had been evacuated before the arrival of the team.

3. The bomb damage at the Sterkrade plant of Ruhrchemi was very severe, so that it was impossible to prepare any kind of flow diagram based on undamaged pipe lines and equipment. On the other hand, bombs had blown open some of the equipment so that some knowledge of internal construction could be obtained that would have been impossible otherwise.

The Ruhrchemie works on the northeast side of the main road passing through the plant comprised a synthetic ammonia plant, a nitric acid plant, research and development laboratories, and a plant for the preparation, regeneration, and reduction of Fischer-Tropsch cobalt catalyst.

The Ruhrbenzin works on the other side of the main road contains the Fischer-Tropsch synthesis plant with its various ancillary units, T.V.P. and Dubbs cracking units, a partly constructed catalytic cracking plant, clay treating unit, a polymer gasoline plant, synthetic lubricating oil plant and the OXO process plant. At the extreme south end is a large unfinished plant for production of toluene from heptane.

Apparatus in the development laboratory could not be definitely identified, but information obtained indicated that work on iron synthesis-catalysts up to semi-technical scale and also work on oxidation of wax had been carried out.

The Preparation and Purification of Synthesis Gas.

The first stage in the process was the production of blue water gas from coke. The battery of generators appeared to be of the standard Humphreys and Glasgow type and were not therefore investigated in detail.

Following the water-gas generator building was the gas holder and the necessary blowers to carry the gas through the purification system. Removal of hydrogen sulphide or "Grobreinigung" was carried out in the usual vertical cylindrical towers containing layers of iron oxide. These were standard design and no detailed examination was made. Following this was the "Feinreinigung" or removal of organic sulphur from the gas. This unit consisted of gas preheaters for heating the water gas to approximately 200°C. before entering the catalytic purification chambers. The chambers were vertical cylindrical towers with the catalyst held in heavy screen baskets in such a way that the catalyst layer was in the form of an annulus in the chamber, with empty gas space between the annular layer and the chamber walls (which were thermally insulated) and also empty gas space in the core of the annular catalyst layer. Later a drawing of this chamber was obtained and will be included in the final report. The preheated gas entered the center gas space and left the chamber through the inner empty core. Two of

these chambers operated in series with a temperature control between the two chambers so that the temperature in each could be regulated independently. Examination of the catalyst showed it to be hard particles about $\frac{1}{4}$ to $\frac{1}{2}$ inch in diameter and of a typical ferric oxide color, and it was expected that later information would show it to be the usual 70% iron oxide-20% sodium carbonate composition.

Following the gas purification units were the towers containing the usual shift catalyst for conversion of the carbon monoxide in the water gas into hydrogen so that the desired ratio of hydrogen to carbon monoxide could be attained for the synthesis gas. Since only a portion of the water gas passes through this conversion plant, by-pass lines were provided so that unconverted water gas could be mixed with converted gas in any proportion to give a desired hydrogen:carbon monoxide ratio. Since synthesis gas was delivered to both the normal pressure and the medium pressure catalyst chamber systems, and since each system might require different ratios, the mixing system was arranged to give independently made mixtures to each.

Normal-Pressure Catalyst Chamber System: (See Fig. 1)

This consisted of 52 catalyst chambers (exact count was difficult because of extensive bomb damage). The general design of these normal or low pressure chambers was fairly well known and furthermore complete drawings of their construction were later obtained from Gutehoffnungshütte at Sterkrade, so detailed data will be omitted in this preliminary report. These chambers were rectangular, about 20 ft. long, 6 ft. wide and 9 ft. high, and were filled with thin vertical steel plates parallel to each other and about $\frac{3}{8}$ or $\frac{1}{2}$ inch apart. Passing through these plates at right angles were numerous horizontal tubes about one inch in diameter, which served to carry the water, the vaporizing of which removed the exothermic heat of the hydrocarbon synthesis occurring in the chambers. Catalyst occupied all of the spaces between the steel plates and these plates acted as heat-transfer fins to carry the generated heat to the water tubes. The water tubes connected to tube sheets located at each end of the chambers, and the generated steam from every pair of two chambers united in a common header on which was an automatic pressure regulator so that the proper steam pressure (and therefore the temperature) could be maintained constant. Two headers (from four chambers) entered an overhead steam drum and from these

drums the steam entered a common steam collecting main for use in the plant.

The tops of each chamber were removable so that fresh catalyst could be charged by gravity flow directly from the large "Kübel" containing it, by means of an overhead crane running the length of the catalyst chamber building. Spent catalyst was removed by means of a drag chain conveyor which could be installed in a trough at the bottom of the chamber and running its full length. Gas entered the chambers at the top and left at the bottom, after passing through the thin layers of catalyst lying between the heat dissipating plates.

The gas connections to each chamber were so arranged that any chamber could be connected into the first stage of synthesis or the second stage or could be isolated entirely. Other gas connections, presumably for hydrogen for regeneration, nitrogen or carbon dioxide for blanketing, etc., were also provided, but it was impossible to trace such lines because of bomb damage.

The above description of the normal-pressure chambers corresponds to that known before the war and apparently no change had been made since that time.

Both the first stage and the second stage outlet mains connected directly to their respective condensers, which were two tall towers situated outside the catalyst chamber house. These were the usual direct coolers with water sprayed into the top and gas passing countercurrent from bottom to top. The tower filling was not examined but it is presumably Raschig rings.

After the second stage condenser the gas passed to the active carbon absorbent chambers where light benzin and C_3-C_4 hydrocarbons (gasol) were removed from the gas. These absorbent chambers were vertical cylindrical tanks about 15 ft. in diameter and 10 ft. high. Since these operated on a definite time cycle of absorption, stripping, cooling, etc., automatic time cycle machines had been installed to automatically open and close the various valves.

Medium-Pressure Catalyst Chamber System.

These chambers which appeared to be about 72 in number were located in an extension of the same building that housed the normal-pressure chambers. The construction details of these chambers were not so well known as were those for normal-pressure, so a more

detailed examination was made. This was greatly facilitated by the fact that one chamber was lying on its side outside the building and was apparently in the process of being re-tubed when the personnel evacuated the plant. This was examined and photographed (see Fig. 2). Also at a later date, drawings showing all construction details were obtained from Gutehoffnungshütte in Sterkrade and this information will be available in the final report.

These medium-pressure chambers were vertical cylinders, 2.7 m. internal diameter, containing 1984 tubes, placed vertically and uniformily throughout the interior of the cylindrical chamber. These tubes were approximately 48 mm. outside diameter and 44 mm. inside diameter and about 4½ m. long. At both the top and the bottom they were welded into tube sheets, the distance between tube centres being 54 mm. Inside each tube was another tube of almost the same length, concentrically placed and about 24 mm. outside diameter and closed at each end. Near each end, however, was a side connection so that the inner tube had free access to the space in the chamber that was outside of the large tubes. Water was kept in the chamber outside of the large outer tubes and this water also flowed through the inner tube by means of the side connections at each end. Between the outer and inner tubes, it is evident that an annular space about 10 mm. wide existed which connected directly to the space above the upper tube sheet and the space below the lower tube sheet, but was isolated entirely from the water system outside and inside of this annulus. This space was filled with the catalyst and the synthesis gas entered the chamber in the space above the upper tube sheet, then flowed down through these annular catalyst spaces and finally left the chamber below the bottom tube sheet. To insure the uniformity of the annular space, small spacing plugs had been welded to the tubes, thereby rigidly holding the inner tube concentric to the outer tube throughout its length. This design of catalyst chamber insures that the maximum distance of any particle of catalyst from a water-cooled surface will not be more than about 5 mm.

Directly beneath the bottom tube sheet is a heavy reinforced screen for the support of the catalyst particles. This screen is separated into eight pie-shaped segments, hinged at the outside so that the segments may be allowed to drop from the center, thereby discharging spent catalyst from the chamber. The sections of the screen are supported by a Y-shaped member resting on a jack screw which passes through the cone-shaped

bottom of the catalyst chamber, which allows the catalyst to be discharged into a container under the chamber.

The top of the catalyst chamber is a large flanged and dished head. The gas inlet is not through this head, thereby allowing easy removal of the head for catalyst charging. Instead, the gas enters through a side nipple just below the head flange. The gas outlet is through a nipple welded onto a manhead located on the conical bottom of the catalyst chamber.

The 72 chambers are arranged in sets of four chambers, each set of four chambers being placed in the form of a square. The inlet gas connections of all four chambers join in a common header and this header is valved so that it may receive first stage, second stage, or third stage gas from the appropriate mains passing through the catalyst chamber house. This indicates that the rotation of catalyst chambers between the different stages and other operations such as regeneration proceed by units of four chambers rather than individual chambers. The only independent valve provided for each individual chamber is a shut-off valve, so that one or more chambers may be cut off from the unit header, if so desired. It follows as a natural consequence that the gas outlets from each set of four chambers also connect to a common header to go to the appropriate outlet main.

The steam from the water section of the chambers is also handled as a unit from each set of four chambers. Outlets from the top of the chamber steam section join in a common pipe for each set of four and this connects in turn to the bottom of a horizontal steam drum. A similar arrangement exists for the bottom of the chamber steam sections.

Experimental Catalyst Chambers.

At one end of the row of medium-pressure catalyst chambers there was discovered one chamber of a rather unusual design that had apparently been installed for purposes of experimentation. As judged from its external appearance, it apparently contained the thin steel plates and horizontal water tubes of the normal-pressure catalyst chambers, but the shell had been built of curved heavy steel plate sections welded together so as to give the outside a corrugated appearance (see Fig.3). It seemed probable that this vessel was the 'Druck-lammellen Ofen' referred to in the S.I.C.S. correspondence, and was an attempt to construct an oven to stand

the higher pressure (20 ats.) required for the iron catalyst process, based on the internal arrangement used for synthesis at atmospheric pressure.

Adjacent to the above vessel was a vertical, cylindrical medium pressure reactor which, it appeared, differed from the normal type only in being fitted with its own, self-contained steam drum which took the form of an annular space round the circumference of the vessel near the top. (see Fig. 4)

In addition to the usual system of condensing towers and active carbon absorbers, an extensive system of what appeared to be condensers, scrubbers, heat exchangers and boosters was found close to the medium-pressure end of the catalyst chamber house and connected to the catalyst chamber gas mains. It was quite impossible to determine the significance of this arrangement by unguided inspection.
