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1914-1915: THE BEGINNINGS OF CHEMICAL WARFARE / CHLORINE GAS

* The history of chemical warfare (CW) traces largely back to a single man: Fritz Haber, who developed poison gases for Germany during the First World War. Haber was a world-famous chemist, who had developed a crucial process for extracting nitrates from the atmosphere. This process was used to manufacture fertilizer, and later to make explosives. Haber was a dedicated German patriot. He had a "Prussian" sense of discipline and duty, enhanced by the fact that he was of Jewish origin, though he renounced the faith in 1902. His minority background led him to want to be "more German than the Germans".

When the war broke out in August 1914, the Germans were confident they would win, but their offensive bogged down into a bloody stalemate of trench warfare in the West. With the front deadlocked, Haber focused his mind on what he could contribute to German victory. He believed that poison gas would penetrate the strongest trenches and fortifications, allowing the German army to score critical breakthroughs through Allied defenses.

Poison gases of various sorts were already available as unwanted by-products of chemical processes. At his Berlin institute, founded by the Kaiser himself, Haber began experimenting with and refining such toxins to find those suitable for battlefield use. He initially focused on chlorine gas, the diatomic chlorine molecule, a highly reactive chemical that was used in the dye industry.

His home was on the grounds of the institute. While work and home life can clash, in the case of Haber the two quickly led to an outright war. His wife Clara was also a chemist, and was as strong-willed as he was. She believed that science should be used for constructive purposes, not to make weapons of mass destruction. Fritz Haber tried to keep Clara in the dark about his work on poison gas. In December 1914, however, there was an explosion in the lab, and one of the workers, a Professor Sachur, was hurt. Clara rushed to Sachur, who was an old friend that in fact she had introduced to her husband. The man died. Clara made her objections to her husband's work plain, but Fritz continued his work on chemical weapons. Their marriage degenerated into warfare.

The startling thing about Haber's work on CW is that he did it on his own initiative. In fact, he approached the German military at the end of 1914 to sell them on poison gas, but the military had no great regard for scientists, and poison gases seemed unsporting anyway. Haber still convinced them to watch a demonstration, conducted at a military testing ground outside Cologne. Clara was present, and her loathing of her husband's activities increased.

With stalemate on the front, the German military could not be certain of victory. Defeat would be the greatest dishonor, so in early 1915 they decided to swallow their scruples and use Haber's poison gas. They gave him officer's rank, and he helped organize a chemical corps.

* The Germans conducted the first chlorine gas attack on 22 April 1915, against French and Algerian troops facing them at Ypres in Belgium. The Germans set up 5,730 cylinders of chlorine gas and opened their valves. 180 tonnes (200 tons) of gas were released, forming a dense green cloud that smelled of bleach and rolled into Allied lines.

At 30 parts of chlorine to a million parts of air, chlorine gas is a nasty irritant that causes harsh coughing. At 1,000 parts per million, it is lethal, caustically stripping the lining from the lungs and causing victims to drown in their own fluids. The results of the gas attack were devastating. The French and Algerian soldiers choked, their lungs burning, and slowly died. The gas cloud tinted everything a sickly green. Those who could escape the cloud fled in panic. Before dawn on 24 April, the Germans poured gas into Canadian lines, with similar results.

Allied casualties in the two days of gas attacks were estimated at 5,000 dead, with 10,000 more disabled, half of them permanently. Despite the fact that the French had captured a German soldier who was carrying a gas mask and who provided advance details of the attack when interrogated, the report was lost in the noise and the soldiers in the trenches had no warning.

The attack was staggeringly effective. Irritant chemicals, essentially tear gases, had already been fired in artillery shells by both the French and the Germans, but they had not proven to be much more than a tactical nuisance to an adversary. Even the German military was astonished by the results of Haber's chlorine gas. To Haber's fury, they were not prepared to exploit the breach they had made in Allied lines, and did not commit any serious force to a follow-up attack. That may have been partly because they didn't have the protective gear for large numbers of troops at the time.

The Germans launched a number of gas attacks during May 1915, with the last taking place on 24 May. The gas attacks then ceased. The prevailing winds over the lines had changed direction, and except for two small-scale attacks in October, the Germans did not return to gas attacks in earnest on the Western Front until December. The attacks in April and May represented a squandered opportunity for the Germans. Had the gas attacks been performed on a larger scale and been followed up, they could have decisively changed the course of the war. In practice, they just made the stalemate even more miserable.

* That was not quite realized at the time, however. German newspapers were enthusiastic over the effectiveness of poison gas, and some even claimed that gas weapons were more humane than bullets and shells. Haber was promoted to captain. He threw a dinner party to celebrate. Clara Haber was not in a congratulatory mood. They had a furious argument that evening, with Clara accusing Fritz of perverting science. He called her a traitor to Germany. Her verbal protests could not sway her husband. That night, she took his army pistol and shot herself through the heart. Fritz Haber left for the Eastern Front the next day, leaving his wife's funeral arrangements to others.

The change in prevailing winds allowed the Germans to use their new poison gases on the Russians. On 31 May 1915, Haber supervised the first chlorine gas attack on the Eastern Front. Gas proved extremely deadly against the poorly-equipped Russians, though it was not very effective in winter cold since it tended to freeze. The Russians ended up suffering more gas casualties than all the other combatants combined, and their attempts to retaliate in kind generally proved ineffective.

[1.2] 1915-1916: ALLIED RESPONSE / PHOSGENE

* The Allies were unsurprisingly outraged at the German use of poison gas. The British Army assigned Major Charles Howard Foulkes of the Royal Engineers to implement a response. Foulkes was energetic and capable, and he quickly implemented schemes for CW defense and offense.

In June 1915, 2,500,000 "Hypo Helmets" were issued to Allied troops. These were primitive gas masks, made of flannel that was chemically impregnated to neutralize chlorine, with eyepieces made out of celluloid. They were far better than nothing, but they could not resist an extended gas attack. Given enough gas, any filter would eventually become saturated and ineffective.

By early fall, Foulkes and his "Special Companies", later "Special Brigades", for gas warfare were ready to respond to German gas attacks with one of their own. On 25 September 1915, the British conducted their first gas attack at Loos, Belgium, using 5,500 cylinders of chlorine gas, in support of a major ground offensive. The gas attack was partly fumbled, with the gas blowing back into Allied lines and other screwups, resulting in thousands of Allied casualties. However, the effect of gas on the Germans was brutal and the Allies were able to quickly overrun the Germans' front-line trenches. It did little good; the British smashed themselves against the German rear defenses and suffered 50,000 casualties. The Germans counterattacked and pushed back the penetrations within a week.

* On 9 December 1915, with the winds again in their favor, the Germans launched another gas attack on the Allied lines, this time against the British at Ypres in Belgium. The Germans used chlorine and a new gas, "phosgene". It was said to have the smell of "new-mown hay".

Phosgene was another industrial chemical by-product that Fritz Haber and his institute had evaluated as a poison gas. Phosgene had a specific destructive interaction with lung tissue, turning to hydrochloric acid when it came into contact with water, and its lethal concentration was only an eighteenth that of chlorine. Its action was subtle and deadly. A soldier who inhaled a lethal dose of phosgene would feel some irritation at first, and then feel fine for a day or two. In many cases, men would simply shrug off the gas attack as inconsequential, or hardly notice they had been gassed. Then the linings of their lungs would break down, and as with chlorine gas they would drown in their own lung fluids, coughing up a watery stream until they could choked and drowned. There is a story of a German prisoner who had been gassed with phosgene and mocked his captors for the ineffectiveness of their gases. He was dead within 24 hours.

Fortunately, the British had realized the summer before that phosgene might be used as a poison gas and were prepared for it. They had developed the improved "P Helmet", with better impregnation and a rubber exhaust tube. Nine million P Helmets had been issued by December, and managed to limit Allied casualties.

The British were quick to adopt phosgene themselves. In June 1916, during the battle of the Somme, they poured out a huge cloud of phosgene and chlorine gas along a 27 kilometer (17 mile) front. The cloud penetrated up to 19 kilometers (12 miles) behind German lines, killing everything unprotected. The British became particularly fond of phosgene.

* In 1915, both sides had only been experimenting with poison gas. In 1916, it became a standard weapon and was used enthusiastically. The British established a large research and development facility at Porton Down on Salisbury Plain for development of chemical weapons.

However, the Allies were at a significant disadvantage in chemical warfare. Germany's chemical industry was the biggest in the world. Germany's eight giant chemical firms were united in a cartel named the "Interessen Gemeinschaft (IG)". The IG was willing and capable of producing large quantities of chemical weapons.

Soldiers hated poison gas, more than they hated most weapons. The trench war was bad enough; gas made it much more dreadful, since digging in provided no defense against it. Soldiers were almost as scared of their own gas as they were of the enemy's, since blunders were common, and shifting winds made gas releases potentially dangerous to everyone. 57 of Foulkes' men were killed by their own gas during the Battle of the Somme. Gas masks were extremely uncomfortable, and the terror caused by gas extreme, particularly after the introduction of phosgene. One soldier recollected: "It was remarked as a joke that if someone yelled 'gas', everyone in France would put on a mask."

There was nothing really funny about the situation, however. In 1918, the British poet Wilfried Owen wrote a nightmare-like description of what it was like to endure a gas attack:

Gas! GAS! Quick, boys! --
**   An ecstasy of fumbling**
Fitting the clumsy helmets just in time,
But someone still was
**   yelling out and stumbling**
And flound'ring like a man in fire or lime --
Dim through the misty panes
**   and thick green light,**
As under a green sea, I saw him drowning.
In all my dreams before my helpless sight
He plunges at me,
**   guttering, choking, drowning.**

[1.3] 1916-1918: THE LIVENS PROJECTOR / MUSTARD GAS

* The combatants continued to improve the technology for CW. In early 1916, both the French and the Germans began firing gas shells out of conventional artillery, and the British began to use gas barrages on a large scale the next year. Artillery shells could not achieve the gas concentrations provided by cylinders, but they could reach far back into enemy lines, reducing the risk of gas exposure to "friendly" forces.

While the Allies had at first lagged the Germans in developing new chemical weapons, they soon came up with innovations of their own. The first was the British "Livens Projector", invented by Captain William H. Livens, a British Army officer who took a personal interest in finding new and more effective ways to kill Germans.

The "Livens Projector" was simply a metal pipe about a meter or so long that was buried in the soil at a 45-degree angle. Large numbers of the projectors were set up in banks. Each projector was loaded with a drum containing about 14 kilograms (30 pounds) of gas, and the bank of projectors was fired by an electrical charge, sending the drums tumbling through air for a range of over a kilometer and a half (about a mile). Each drum contained a bursting charge to blast it open when it landed near enemy trenches, dousing the enemy with gas with little warning. The Livens Projector was cheap, crude, and extremely effective, since it could be used in mass numbers to produce an overwhelming, terrifying barrage. It was first used at the Battle of Arras on 9 April 1917. As a witness observed:

BEGIN QUOTE:

The discharge took place practically simultaneously: a dull red flash seemed to flicker all along the front as far as the eye could reach, and there was a slight ground tremor, followed a little later by a muffled roar, as 2,340 of these sinister projectiles hurtled through space, turning clumsily over and over, and some of them, no doubt, colliding in flight.

About 20 seconds later they landed in masses in the German positions, and after a brief pause the steel cases were burst open by the explosive charges inside, and nearly fifty tons of liquid phosgene were liberated which vaporized instantly and formed a cloud that Livens, who watched the discharge from an aeroplane, noticed it still so thick as to be visible as it floated over Vimy and Bailleu villages.

END QUOTE

The British became very competent at setting up and using massed Livens Projectors, and developed a variety of projectiles for the weapon. The Germans tried to copy it, but the Livens Projector gave the British an edge on the Germans in gas warfare and the Germans never quite caught back up.

* The Germans had another trick of their own, however. On the evening of 12 July 1917, the Germans fired shells into British trenches at Ypres, but when they burst the shells released a brown oily fluid, not a gas. The stuff had a horrible smell, something like rancid garlic or mustard, but it otherwise didn't seem particularly offensive and caused only slight irritation to eyes and throat. Remarkably, given the paranoia over gas attacks, many British troops didn't bother to put on gas masks. As the night wore on, they began to feel pain rising in their eyes and throats, and gradually suffered swelling and huge blisters wherever their skin had come into contact with the noxious fluid.

The results were horrendous, with all affected losing large patches of skin and many of the men blinded. Some died from the massive damage done to throat and lungs. The actual number of fatalities was low, but many of the victims were so badly hurt that they would not be fit to fight for months, if they ever recovered their health at all.

The Germans called their new weapon "Lost", or "Yellow Cross" after the marking on shells, in contrast to the "Green Cross" that designated chlorine and phosgene. The French quickly named it "Yperite", after its use at Ypres. The British codenamed it "HS", for "Hun Stuff", but its rank smell inspired another name that stuck: "mustard gas".

Its formal name was "dichloroethyl sulfide", and it had been discovered by accident by chemical researchers before the war, some of them being badly burned by it. Mustard was not used in its formulation; the smell was simply a coincidence, and was actually due to impurities that arose in its formulation. The pure agent actually had little or no smell.

Mustard was a "blistering agent", or in formal medical terms a "vesicant" -- in essence it caused chemical burns. It had actually been evaluated by the British some time earlier and rejected as insufficiently lethal. In fact, although mustard gas didn't have the killing power of phosgene, it was still a very useful weapon. The Germans had realized that improved Allied gas masks and training had rendered chlorine and phosgene gas ineffective. Haber then put his skills to work to develop a chemical weapon for which a gas mask could offer no protection.

Mustard gas did not dissipate like the other gases. The oily fluid could persist for a long time and continue to cause misery and pain to anyone who came in contact with it, for example accidentally getting some of it on his boots and from there on his hands and face. It would freeze during the winter, and still be toxic when it thawed again in the spring. In fact, French citizens are still occasionally suffering chemical burns from stumbling across ancient dud mustard shells plowed up on old battlefields.

Mustard gas was a vile substance, and manufacturing it was difficult and dangerous. The French were not able to begin full production of it until June 1918. The British built a large plant at Avonmouth to manufacture mustard gas. The gas would cost workers at the Avonmouth plant three deaths, a thousand burns, and endless illnesses, some of which would plague their victims all their lives. The British Army did not obtain mustard gas until September 1918, and the Allies never seriously used mustard gas in combat. They made do with phosgene with a vengeance. In early 1918, the British responded to the German mustard gas attacks with dense clouds of phosgene to overwhelm gas masks, with the poison released from big cylinders on train cars rolled up behind the lines.

The Americans were laggards at chemical warfare. They set up a "Gas Service" after they entered the war in 1917, which led to the "Chemical Warfare Service (CWS)" in 1918. The US Army was not all that enthusiastic about CW, largely because frontline officers had noticed the Germans became particularly annoyed when gassed, responding with furious heavy artillery barrages.

* The Germans launched their last major offensive in the West in March 1918. After initial success, the offensive fizzled out and the Allied armies, now heavily reinforced by the Americans, pushed back the Germans relentlessly. By this time many of the artillery shells fired contained gas, with the proportion as high as a third or even half. However, it hadn't proven a decisive weapon and had done little more than make conditions worse for the soldiers in the trenches.

Gas could be highly effective if it was used against opponents who were not equipped to deal with it. As mentioned, the Germans used it with great effect against the Russians, inflicting what is now broadly estimated to be about 600,000 casualties, and in October 1917, the Germans used phosgene to break the Italian defensive line in Northern Italy at Caporetto. The unprepared Italians were sent into terrified flight and decisively defeated. In contrast, troops who were equipped and trained to deal with gas attacks would suffer relatively minimal casualties, though bundling up against gas was stifling and exhausting, and life in a poisoned landscape was demoralizing.

Yet the gas shells kept flying overhead. One small incident stands out. On 14 October 1918, the British fired their new mustard gas shells into German positions at a Belgian village named Werwick. One of the injured was an Austrian-born corporal named Adolf Hitler, who wrote vividly in MEIN KAMPF that at "about seven o'clock my eyes were scorching ... a few hours later my eyes were like glowing coals, and all was darkness about me." He was evacuated back to Germany by train a few days later, blinded, burned, and seething over his humiliation and the humiliation of his beloved Fatherland.

An armistice was declared in November 1918, and the shooting stopped. Gas was estimated to have killed about 100,000 men and injured a million. The number of men killed by gas was small compared to the number killed by other means, but gas had played a particularly unpleasant role in the conflict. Gas shells and other delivery systems had been refined, as had defensive technologies and procedures. All the combatants had been preparing even nastier chemical weapons when the war ended.

[1.4] 1918-1934: CW IN THE AFTERMATH

* Fritz Haber was devastated by his country's defeat. He feared that he would be tried as a war criminal, and left Germany for Switzerland wearing a fake beard. Haber needn't have worried. In 1919 he was awarded the Nobel Prize in chemistry instead, for his prewar development of the Haber process. He was restored to respectability, though there were loud protests at the award. Haber himself was anything but contrite and did not avoid the subject of CW when he received the prize, saying: "In no future war will the military be able to ignore poison gas. It is a higher form of killing."

They were hardly ignoring it. Four classes of agents had been developed during the war and were being refined in the postwar period:

- Asphyxiants or "choking agents", which attacked the lungs and could cause victims to drown in their own lung fluids. The classic agents were chlorine and phosgene, but other agents were used during the war. "Diphosgene" was similar to phosgene in composition and action, but easier to handle.

  "Chloropicrin", known as "vomiting gas" by the British, "aquinite" by the French, and "klop" by the Germans, was much less effective than phosgene and had a nasty strong odor that gave away its presence, but it was inert; it could penetrate gas mask filters more easily and was sometimes used in combination with other gases.

- Blistering agents, consisting of several different forms of mustard gas. The original German chemical agent was "sulfur mustard", but after the war "nitrogen mustard" agents were synthesized and manufactured as well. Nitrogen mustard was easier to manufacture and more persistent than sulfur mustard.

  The Americans did make a significant contribution to CW in the form of a blistering agent named "lewisite", developed in 1918 by W. Lee Lewis of the Catholic University in Washington DC. Lewisite was similar to mustard gas in its ability to cause damage to a victim's entire body, but much faster-acting, though apparently it degraded easily when it came into contact with water.

  Lewisite was an oily liquid that ranged from clear to dark colored, depending on impurities. Pure product had little smell, but impure product smelled something like geraniums. It was an arsenic-based or "arsenical" compound that caused a burning sensation on the skin within about 15 seconds. The Americans built a huge production facility at Edgewood Arsenal to manufacture lewisite in quantity. It was too late in the war to get it into service and the Americans blessedly gave up its production soon after the end of the conflict. However, they had let the genie out of the bottle and other nations would find lewisite very interesting.

  A family of other broad-effect irritants were developed in the postwar period as well, known as "nettle gases" since they made a victim feel as if he had been dragged through stinging nettles. The best-known of the nettle gases was "phosgene oxime". The name is somewhat misleading since it had no strong chemical relationship to phosgene, and of course had a much different action.

- Blood agents, most specifically aqueous "hydrogen cyanide (HCN)", also known as "prussic acid" or "hydrocyanic acid", which blocked the absorption of oxygen in the blood. Cyanides had been used in combat by the Allies to an extent, but though deadly in enclosed spaces, they tended to dissipate quickly in open air, and they had little useful effect in low concentrations.

- A wide range of "nonlethal", or more correctly "less lethal", gases, including tear gases and vomiting agents. Such substances are now known as "riot control agents (RCAs)". Many different tear gases were used during World War I, such as "chloracetone" and "bromacetone", and after the war new tear gases were developed, including "chloracetophenone (CN)" and "ortho-chlorobenzylidene malononitrile" -- the second being an aerosol powder mercifully better known as "CS" after its inventors, Corson and Stoughton. CN is actually the basis of the popular self-defense spray known as "Mace", and CS remains in use by the US military as an RCA and for gas training. By the way, modern "pepper spray" is actually based on a substance named "capsaicin" that's the active ingredient of chili peppers.

  One of the best-known vomiting agents was "adamsite" or "DM", an arsenical like lewisite. Vomiting agents tended to be more lethal than tear gases and they were eventually abandoned.

Incidentally, formally the term "chemical weapon" does not mean a poison gas in itself. It formally means a weapon used to deliver poison gas, such as a shell or a gas cylinder. The poison gases are formally referred to as "chemical agents".

Rumors linger that gas warfare continued in the confused years immediately after WWI, if on a very small and quiet scale. Gas shells may have been used in the Russian Civil War by both the White and Red armies, and may have been used by colonial powers on occasion to help suppress rebellious populations.

Fritz Haber continued his work on poison gases under the cover of "pest control", since gas weapons had been forbidden to the Germans by the Treaty of Versailles in 1919. Haber developed an insecticide that could be used to fumigate buildings, in the form of a crystalline material that released hydrogen cyanide fumes. It could also be deadly to humans in enclosed spaces. It was known by the tradename of "Zyklon B", and the Nazis would find it a useful substance for their extermination camps 20 years later. Although hydrogen cyanide was a poor battlefield agent, it would almost certainly end up killing more people than all other poison gases ever used.

* If gas warfare continued in secret, in public it was made illegal through a series of international treaties that culminated in the Geneva Protocol of 1925. 38 countries signed the protocol, renouncing the use of chemical weapons, though the treaty was not ratified by the US and Japan.

There were major loopholes in the treaty; it had few or no verification or enforcement clauses; and the major powers continued to develop chemical weapons in secret. During the late 1920s, the Soviets began to develop their own gas warfare capability with cooperation from Weimar Germany, and in the same timeframe the Japanese obtained their own gas warfare capability. The Japanese were industrious in their chemical weapons efforts, producing mustard gas and lewisite; chemical bombs, rockets, aerial dispensers, anti-tank grenades using hydrogen cyanide charges, and other weapons; and chemical protection gear not only for men, but for horses, camels, and dogs.

When the Nazis came to power in Germany in 1933, they were very interested in gas warfare. Hitler had been impressed by its capabilities after his incapacitation by a gas attack, and in the form of Fritz Haber, Germany possessed a great resource for chemical warfare. However, Haber's Jewish background made him distasteful to the Nazis. His stature was such that he was told he could remain in charge of his research, but that all his Jewish workers must resign. He replied that he

would resign as well. He left Germany, and died in Switzerland the next year, in 1934. His instructions indicated that he was to be buried next to Clara.

[1.5] 1934-1940: NERVE GAS / REVIVAL OF GAS WARFARE

* Gas warfare continued to evolve without Haber. Another German chemist, Gerhard Schrader, was honestly working on insecticides when he developed a highly lethal organophosphate compound in December 1936, which he named "tabun". He found out how potentially deadly it was in January 1937, when he and an assistant accidentally spilled a drop of it. Their pupils constricted to pinholes and they suffered shortness of breath. Had the spill been slightly bigger, it would have killed them.

Tabun was the first member of a fourth class of poison gases, known as "nerve gases", or more correctly "nerve agents", since they were dispersed as a fine aerosol of liquid droplets, not a gas. The Germans discovered a few years later that tabun worked by interfering with the transmission of nerve impulses across synapses. Victims lost bodily control until they were no longer able to breath, causing suffocation. Tabun was invisible, odorless, and could kill in extremely tiny quantities. A gas mask was little protection, since tabun could be absorbed through the skin.

Tabun was far too dangerous to be safely used as a pesticide. Although Schrader had not been looking for a weapon, he realized the military potential of his discovery. He was a dutiful German and reported his discovery to the authorities, as required under Nazi law of any discovery that might have military applications. Schrader was not enthusiastic about developing chemical agents like Haber, but he did it anyway. The Nazis set him up in a secret military research lab. In 1938, he discovered an even more lethal nerve agent similar to tabun, which he named "sarin".

* In the meantime, CW had resurfaced. The Italians used mustard gas during their campaign in Abyssinia (now Ethiopia) in 1937. They introduced the new trick of dropping it from airplanes in gas bombs. World opinion condemned Mussolini. Beginning in 1937, the Japanese also began to use gas weapons against the Chinese. China was remote and backward, and so information on the Japanese use of gas was sketchy, but reports trickled out of mustard gas attacks on Chinese soldiers and citizens.

CW was coming back into style. A big conflict was coming, and chemical weapons were expected to be used, both on the battlefield and against civilian populations. The British distributed 30 million gas masks, not knowing how useless they would be if the Germans used their secret new tabun gas, and implemented an exhaustive CW civil defense program. Governments also ramped up development and production of chemical agents.

One of the more bizarre bits of evidence of the fear of chemical warfare in the prewar period was a gas mask designed for children by the Walt Disney company in the United States. It was in the shape of Mickey Mouse's head, with a picture of Mickey labeled on the filter canister, and was clearly intended to make children more enthusiastic about wearing the thing. It never went into production, and in hindsight lends a certain creepy black humor to the matter.

* Tabun wasn't available for operational use when war broke out in September 1939, but the Germans had a chemical corps, which conducted field exercises using mustard gas. However, gas is basically a siege weapon, intended to root out troops dug into trenches and fortifications, and the German Blitzkrieg was war of rapid mobility. Gas could hamper the attacker as much as it hurt the defender, and so it was not used as a firstline weapon, though there are tales that it was used in a few cases against Soviet troops holed up in fortifications.

The Germans stockpiled poison gases in bulk anyway. In January 1940, the Germans began high priority construction of a huge tabun plant at Dyenfurth-am-Oder in Silesia, now part of Poland. The plant was designed to perform all phases of tabun production, though a long series of production glitches kept it of operation until April 1942.

Producing tabun was no simple task. Some of the intermediate chemicals were extremely corrosive, requiring vessels lined with silver or made of quartz. The final product was so incredibly toxic that final production was in rooms with double glass walls, with pressurized air circulated between the walls. Sarin was even harder to manufacture, and though a pilot production facility was built at Dyenfurth, sarin never reached production status during the war.

The production spaces had to be decontaminated every now and then with steam and ammonia. The workers had to wear rubberized clothes with respirators, and the suits had to be disposed of after their tenth use. If a worker was contaminated, his protective clothes were quickly stripped off and he was dunked in a sodium bicarbonate bath. There were a number of accidents at the Dyenfurth plant that killed at least ten workers. One had two liters (half a US gallon) of tabun pour down the neck of his suit. He died in two minutes, despite all attempts to save his life.