

## **FIRES IN SWEDISH MATCH FACTORIES IN THE 1920's CAUSED BY WHITE PHOSPHORUS-CONTAMINATED RED PHOSPHORUS**

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### **ABSTRACT**

Rediscovered documents reveal problems in the Swedish match industry due to contaminated red phosphorus in the 1920s.

Over the years, more than 150 match factories were established in Sweden. In the 1860s, the production of safety matches requiring red phosphorus in the friction composition began to soar. The cheaper phosphorus matches with white phosphorus in the head composition were also produced until the white phosphorus ban phased them out in the 1910s. In factory buildings where phosphorus matches were produced, fire accidents often occurred.

During the first world war, Sweden was blockaded by the Allies England and France, and could at the end of the war only import raw materials following the Swedish "Modus Vivendi agreement". After the war, chemicals that could be imported were of poor quality. As to red phosphorus, the match industry had to learn how it should be purified.

In the spring of 1922, the problems caused by impure red phosphorus escalated, and whole consignments of red phosphorus batches had to be returned to the producer in Germany.

On the 30th of May 1922, Växjö Match factory burned down. To protect the small town from a devastating fire, over 1200 available personnel were put to work at night in order to fight the fire. The police investigation the next day could not conclude any reason for the outbreak of the fire. The day after, boxes with red phosphorus that had been moved to a safe place far away from the fire, ignited spontaneously.

On the 16th of June 1922, a head office memorandum was sent to the Swedish match factories urging them to hermetically solder those metal boxes that contained red phosphorus of poor quality and store them separately.

On the 24th of July 1922, one match factory reported on a test delivery of 500 kg of red phosphorus that it was contaminated with white phosphorus and therefore unlawful to use.

### **HOW I BECAME INVOLVED**

In the 1960s, an elderly man related to me how match waste was handled in the 19th century. His stories awoke in me as I in the spring of 1998 had a cancer tumour removed.

After the operation I was sitting with new friends in the Växjö hospital, looking out over the surroundings. We talked about the town, the people walking around the Växjö Lake,

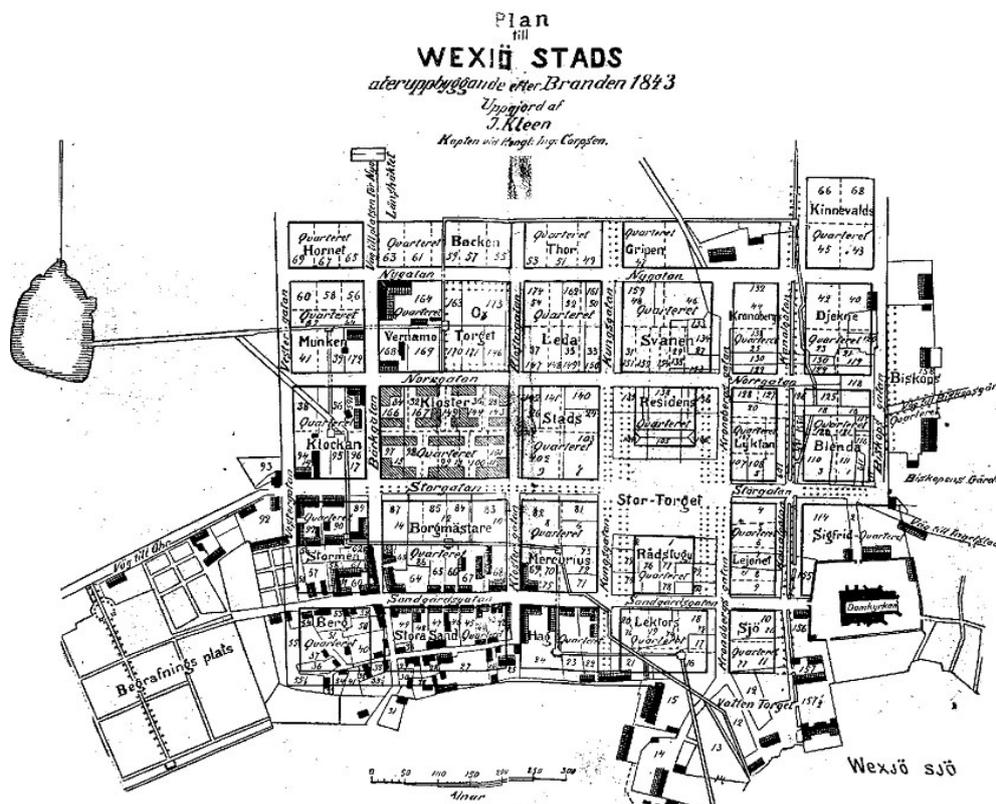
children playing in the park of Strandbjörket... and I remembered the stories I was told in the 1960s. Those children were playing on top of waste that was placed there in the 19th century – three old rubbish heaps, and between them the dredgings from the Växjö lake.

After being discharged from the hospital, I started to investigate how waste from the match factory was disposed of in the 19th century, and found that burying in swamps was the preferred method. According to the old man, a big empty barrel without lids was pressed down a bit in the wet ground. Waste was then poured through the barrel, which was used as a tube, and sank into the ground. Finally, some sand was shuffled after the waste.

Why was the old man involved in a notable transport in the early 1920s? Secrecy was ordered by a person of high rank unknown to him. Tins should have been transported from Växjö to a location near Kosta, where they were buried in the wetness close to a mere. “Where the person of high rank” clearly marked out the place on a map; why?

### MATCH FACTORIES PRODUCING PHOSPHORUS MATCHES

In the 1830s bookseller C. G. Södergren (1807-1886) in Växjö became friends with one of the students at Wexjö high school, Johan Edvard Lundström (1815-1888) from Jönköping – later known as “the father of the Swedish match industry”. The friendship established between them is evidenced by numerous saved letters, exchanged between the two families. (VSB SA)



City plan of Växjö from the year 1843.

In 1843, the production of phosphorus matches are mentioned for the first time, in a report by the Swedish National Board of Trade. The year after, Professor G. E. Pasch in Stockholm patented his safety match in which phosphorus in the unpoisonous red allotropic modification was used for the striking surface on the match-box.

In 1845, J. E. Lundström started his match factory in Jönköping. The phosphorus manufacturer A. Albright in Birmingham patented 1851 a process for the production of red phosphorus. Being the supplier of white phosphorus to the match factory in Jönköping, he offered to it the new product. At the world trade fair in Paris in 1855, the match factory in Jönköping then introduced, what years later was to become the famous, Swedish safety match.

In the 19th century, the popular and cheaper phosphorus matches were the main product of the Swedish match factories. But the demand for safety matches grew steadily, not least due to the banning of phosphorus matches in country after country. At the end of the century, the Swedish safety match had taken the lion's share of the market.

Over the years, more than 150 match factories were established in Sweden (Appendix 1). Many of the Swedish counties had match factories in what today are town centres.

In the 1860's, phosphorus necrosis – the phossy jaw illness – among match factory workers escalated. The authorities began to tackle the problems connected with industrial hygiene as well as those connected with the environment outside match factories.

On the 18 February 1870 came the Swedish Royal Decree for match production and for other ignition compositions containing white phosphorus (VLA JöV FVIII). The decree stated that:

- Phosphorus was only to be handled in factories that were built for such production.
- Phosphorus should be stored separately under a safety lid, fire safe and frost-free.
- The production manager should have chemical knowledge, verified by a higher institution.
- The factory should be situated on a free and dry place. The different manufacturing processes should be performed in separated, ventilated rooms with ventilation hood over the work places.
- The working rooms should have non-inflammable materials on surfaces, a ceiling height of 10 feet and a floor space of minimum 30 square feet per worker.
- The working room and working places should be cleaned every day.
- The working room surfaces should be washed every two weeks.
- The workers should wear working clothes that were cleaned every day
- The working clothes should be changed and kept in separate rooms when not used.
- The workers should have access to clean water and washrooms.
- The workers exposure to phosphorus should be documented. Work with phosphorus was maximised to 6 months intervals, separated by minimum 2 months of other work.
- Health control by a factory physician was compulsory and should be made every 3 months.
- All waste should be burned immediately, water used for washing and cleaning should be poured into a separate, deep well.
- The production was only allowed after approved inspection.
- A Magistrate of a city, a City Administration or a County Police Commissioner should do the inspection and completely document observations made.
- A substantial fine was coded for trespassing.

## “THE MATADORS”

In 19<sup>th</sup> century, three mens work and fighting spirit was popular amongst Växjö people, who called them “The Matadors”. Among other things they saw to it that factories were founded.



*Bror Fredrik Ekeroth,*



*Carl Schander*



*Carl Gustaf Södergren*

Bror Fredrik Ekeroth (1817-1883) was a pharmacist, the first bank director of Skånes Enskilda Bank in Växjö and, through his son, owner of the newspaper “Smålandsposten”. Ekeroth was also a member of the County Administration. He promoted the ideas of a hospital and of shools, that open sewers and the Växjö lake should be cleansed.

Carl Schander (1828-1898) was a trader, owner of the Wexjö Match Factory, the Wexjö Engineering Plant, a cigar factory and the estates Gårdsby, Ringsberg and Westergård. He was also a protector of the world famous soprano Christina Nilsson. Thanks to his engagement, waste handling and water treatment problems were approached.

Carl Gustaf Södergren (1807-1886) was a bookseller and a printer. His historical and technical knowledge, not to mention his net of contacts and acquaintances, made him always the one to be asked. He investigated and cleared up several of Växjö’s historical ownership.



*North the Göl  
Schander’s  
Estate  
Ringsberg*

*Dg, Dh, Di and  
Dk formed the  
first WTF  
round.*

*Ödman is  
Schander’s  
Estate  
Westergård.*

*The western  
suburbs of  
Växjö in 1867.*

After April in 1868, no rain fell in the southeast of Sweden. By August, people were starving, and in October the first death caused by starvation was registered. Wexiö Match Factory (WTF) was established this “year of famine” in the western suburbs of Växjö, near the Växjö pond. The following year, 1869, emigration from Sweden began to escalate.

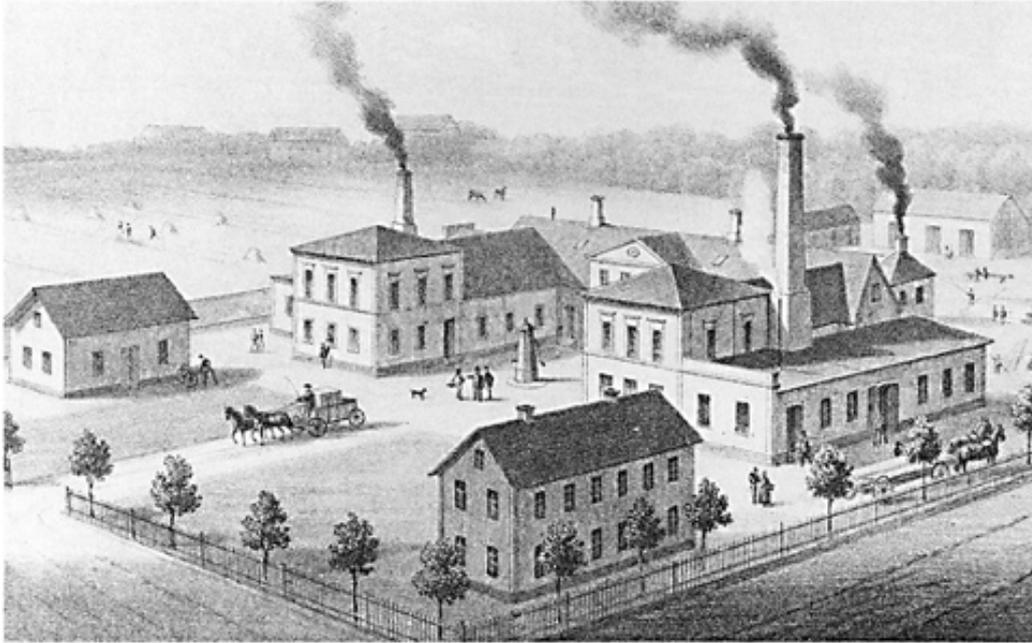
On the 28th of November 1868, six months after the permission to build the match factory was obtained from the Wexiö Magistrate, the first match consignment left WTF. (VSB SA)



*Wexiö  
Match  
Factory,  
WTF, in  
1868.*

On the 17 juni 1870 was WTF inspected, following the 1870th Swedish Royal Decree. In the inspectors handnote is written: “The workers who had to work in the presence of the phosphorus fumes covered their mouths with a box filled with sponge, which was moistened with turpentine.” An early use of gas masks! Turpentine dissolves white phosphorus (VLA WRM). To handle the phosphorus gases the first expansion of the WTF factory now takes place, and for ventilation an electrical ventilation system was installed instead of the in those days only known draught chimney that was fired from a separate fireplace.

In the 1870s, WTF was the pride of Växjö. Visitors coming to Växjö on the western main road entered the town centre on a linden avenue. On its northern side the match factory’s symmetrical buildings could be seen with its architectonically remarkable and representative form.



*WTF 1873  
From Pabst:  
“Sveriges  
industriella  
etablissemang”*

In march 1875, the county governor confirmed Växjö’s fire rules.(VLA VRM FV) Indoor storage of combustible material was now limited to the daily need. All other storage should be in a vault cellar or in a stone-built house without fireplace. Traders were allowed to have 2’000 foot-pounds (850 kg) in a building on the same site. Outdoors, and at least 10 feet from such a building, the allowed quantity was unlimited, provided the material was buried and covered with 2 feet of earth or sand.



In February 1875, 46 women died in a fire accident in the Tidaholm match factory. It was at once decided that all Swedish and Norwegian match factories must be inspected regularly (the two countries constituted a union). The former founder of the match factory of Jönköping, J. E. Lundström, got the job as the union’s first match factory inspector. During the following two years, all match factories on the Scandinavian peninsula were rigorously inspected (RA KR Civildep)

In 1877, Lundström’s report over all the 41 Swedish match factories that were in production were announced in the Swedish cabinet meeting. (RA KR)

*Johan Edvard Lundström*

### **CALEB WARREN & CO/ SMC, London**

In 1887, Schander sold WTF for £ 40 000 to the Caleb Warren & Co in London, Warren acted as a representative for the real owner, the Swedish Match Company Ltd (SMC) in London. Schander remained as manager until 1891.

Four years later, a fire started in a drying box for splint. The box and the ceiling in the splint hall were destroyed. A possible cause for the fire was that a phosphorus match had found its way into the fresh-cut splint that was to be dried in the drying-box. (SSA SAB WTF)

From the 1st of July 1901, the Swedish phosphorus ban came in force: after that date it was prohibited to sell in Sweden matches containing white phosphorus in the ignition composition. Production for export was allowed until 1920 (but was discontinued earlier).



(RA KR Civildep)



*Phosphorus matches and a phosphorus match label from WTF*

In 1913, the production of phosphorus matches ceased at WTF (Smp 1918). The reason was that the U.S.A. had – as did Russia – chosen the method of taxing these matches out of existence..



*Model of WTF in 1901, built according to the author's reconstruction. (SM)*

### **IVAR KREUGER – FROM FSTF to STAB**

In the beginning of the 20th century, the Swedish match factories were arranged in two separate groups of companies. The Jönköping & Vulcan, or JV group, was established in 1903, and consisted of eight factories located at Anneberg, Jönköping, Tidaholm, Uddevalla and Westervik. Ten years later, Ivar Kreuger counter the JV group by establishing the United

Swedish Match Factories, FSTF. This group united factories in Gothenburg, Grantorpet, Kalmar, Lidköping, Malmö, Mönsterås, Nybro, Vetlanda and Växjö.

In 1914, Kreuger presented a modernisation program for FSTF. With an investment of SEK 1 300 000, the yearly earnings expected to be SEK 500 000, *i.e.*, pay back in 2,5 years. (VLA JoV)

In 1915, there was a tough negotiation with England about the Swedish need of access to the sea in order to carry on the shipping trade. It led to the Swedish War Commerce Laws. A temporary agreement with England in May 1916 opened for import from the U.S.A. In July 1916 the allied England and France annulled the London declaration (right of passage) of 1909, and the Paris declaration of 1856. The war led to that the Swedish folk economic administration was nominated in September 1916, and food and raw material became rationed.



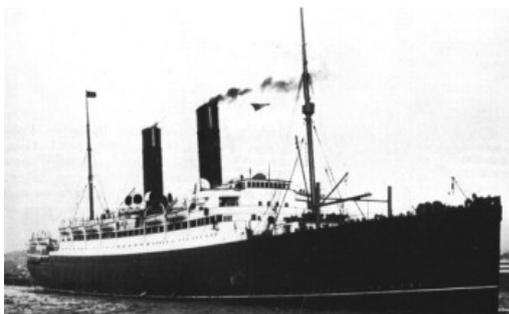
(RA UD1902)

*As it had proven impossible to obtain new supplies of some of the chemicals used in the striking surface on the matchboxes, the decision was taken to limit the striking surface to one side of the box.*  
*Announcement in December 1916 by JV TFAB/AB FSTF.*

In February 1917, J.Hellner and M.Wallenberg submitted a Swedish trade proposal, which England accepted. But the Swedish government Hammarsskjöld couldn't balance the left-wing forces and fell on the costs for the Swedish neutrality guard. The next government Swartz-Lindman fell in the general election in September and as U.S.A unveiled the transmission by the Swedish foreign ministry of German-coded telegrams – the Luxburg affair –, all communication with the Allies was stopped. The new Swedish government – Eden-Hellner-Branting was pressed to start negotiation with the Allies about the most necessary goods to be imported. The negotiations were balanced to avoid an open break with Germany who offered to supply Sweden over German harbours. (RA UD1902)

The JV group chose to divide their import between the two combatants. The Allies punished them for this by refusing to export the required raw materials to them. At the end of 1917, JV had no paraffin or phosphorus left. Officially, FSTF kept their purchase on the Allies' side. The blockade during the war made it necessary to rationalise the purchase of raw materials. Being under the samwards, an international match trust was established by the Swedish Match Co(STAB). STAB's profit was reinvested in raw materials, energy, transport and sale.

### THE SWEDISH “MODUS VIVENDI” AGREEMENT IN 1918



In 1918, Sweden agreed to transfer Swedish ships to the Allies in accordance with the *Swedish Modus Vivendi* agreement. (RA UD1902)

The first agreement ratified in March 1918 (“the small negotiation”). Its main parts were secret;

100 000 Swedish ship tonnage were transferred to the Allies for three months. Sweden was allowed to import 75 000 tons of goods. The announcement caused a threat from Germany

The second agreement was made in May (“the big negotiation”), and was in the main parts strictly secret. A tonnage of another 300 000 was now additionally transferred to the Allies for 12 month. A credit and export privilege was given to the Allies. Import of 1 million tons of goods were strictly regulated and handled by special offices in London and Washington.

Of the transferred ships, 4 % were sunk by mines and German submarines.

During the war, bones were again being used as raw material for phosphorus production for the match industry. In April 1918, the FSTF purchase department announces that 60 tons of phosphorus is enough for 8.5 months of production.

FSTF issued a secret “Circular 15” about the lack of chemicals. Secret “Circular 16” of April 27, 1918, called for a three-day working week, added a fringe benefit of 10 %. Two next days of the week are paid with 60 % of an average by the day wages. (VLA JoV FIV)

In order to free the corresponding amount of bones, FSTF began trials with phosphorus made from raw phosphate. (VLA JoV ED)

In August, FSTF announced by secret “Circular 17” that raw materials have been secured with the effect that the working week can be extended to four days. Friday and Saturday are now paid with 60 % of the average wages. (VLA JoV FIV)

The match factories provide their workers with daily food rations. But this autumn of 1918 there is a great shortage of food in Sweden. In addition, half a million people caught the Spanish flu and over 18 thousand people died.

FSTF’s “Circular 51” in September effects that the quality problems of the imported as well as the Swedish amorphous phosphorus are thoroughly analysed. (VLA JoV EVII)

Ivar Kreuger himself puts forward the idea of using apatite for phosphorus production, and in October he asks the Trollhättan phosphorus factory to find out whether this can be possible.

With the issuing of “Circular 66”, the Swedish match industry begins to rationalise and unify the different factory receipts of ignition and friction compositions. (VLA JoV EVII)

## AFTER THE WAR

The problems during the First World War led to a modern economy with monthly balance of the books. The different goods and quantities are figured out according to what is taken out and given into the stores. Twice every year, on the 30th of June and 30th of November, the whole stock has to be weighed and audited. According to these monthly inventory lists there is multiple index that gives a good picture of the raw material assets and the consumption. (VLA JoV)

VARUSLAG	Tillkommet under mån.	Lagrets medel 3-pris Kronor	Förbrukning för:				Behållning	
			Tändsticksfabrikation		Andra ändamål		Kvant.	Kronor
			Kvant.	Kronor	Kvant.	Kronor		
<b>Svarvvirke</b>								
Barr	Kbm.							
Löv	"	143,54	40 --	600,14	20.005 60	33	1320	1988,61 79284 40
<b>Kemikalier</b>								
<u>Paraaffineringsmedel:</u>								
Harts amerikansk	kg.		- 30	118	34 60			281 ✓ 84 30
" fransk J.V.T.	"		- 30	10	3 --			-- --
Hartsblandad olja	"							
Paraffin, smältp. 109½° F.	"		- 48					2269 ✓ 3721 05
" " 110-118 " "	"		- 48	3166½	1424 83			-- --
" " 118 " "	"	1006	- 48	606	275 20	400	1600	-- --

*The FSTF inventory list of 19 April 1919.*

But better quality of amorphous phosphorus was still the most urgent thing.

Manager Modig at Fredriksdal's match factory offers in 1919 an advise in FSTF "Circular 102" (VLA JoV EVII) :

*Due to the inferior quality of the phosphorus we have to work with, we have for a long time been forced to wash the phosphorus in two waters before using. We have observed that from 10 kg of phosphorus, we obtained 2–3 % phosphoric acid in the first 15 litres of water. The second 15-liter portion of water contains a negligible amount of phosphoric acid, but the washing should be carried out. Comparison between the ability of washed/unwashed phosphorus to absorb water:*

*Place the phosphorus over water, under a glass bell, for some days. The washed sample does not absorb any moisture, but the unwashed one absorbes up to 27 % of water.*

*After the test, the washed phosphorus was in powder form as earlier, while the unwashed sample had degenerated into a paste form, which after a time became liquid delinquent.*

FSTF's "Circular 105" of October 1919 gives instruction for joint formulas for the brown safety mixture and for the striking-surface mixture. Before the new formula for blends are introduced into the production, every factory had to make their own test batches of safety and striking-surface compositions. This work resulted in adjustments, and with "Circular 114" comes more strict analysis methods; all tests should be made in running number, and all possible information should be given as size, deliverer, purchase place, etc. (VLA FSTF)

The correspondence between the factories shows a secondary development of the compositions and new developed techniques for applying the mixtures on sticks and boxes.

## **VISIBLE PROBLEMS WITH RED PHOSPHORUS**

In 1920 a fire broke out at WTF. It started in a wooden drum situated between the steam engine room and the production room for miniature matches. (VKA BS)

The phosphorus quality, led in March 1921 to FSTF-Purchase "Circular 16 and 19". Urgent is asked for further investigations of the batches of phosphorus;

- 1. How large is your stock of German red phosphorus?*
- 2. Do you have in stock any of the red phosphorus from Trollhättan or from England?*
- 3. Do you think that any quantity, according to your own opinion, could not be used? What else in this case do you have to communicate?* (FOAK WTF)

## **WTF BURNS DOWN ON MAY 30, 1922**

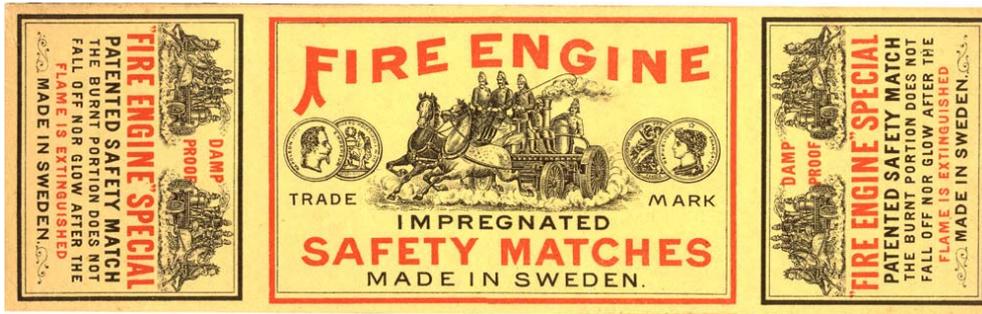
(VLA, VKA, FOAK, Smp, NVB)

At WTF this Tuesday, the daily work finished at 5 PM, and Sven Jakobsson, the night guard, started his rounds. Every half hour he walks a 12 minutes round. He passes first through the 20 m wide splint hall with its splint lathe and four splint-polishing drums (three bigger and one smaller, named roller) and also eight splint dryers (for drying splint impregnated with phosphate for after-glow prevention).

Cam radiators heated the drying boxes. The heating tubes were installed in the floor. Before the heat came onto the splint, it was mixed with cold air to become dry. The westernmost drying box had not been used for a while.

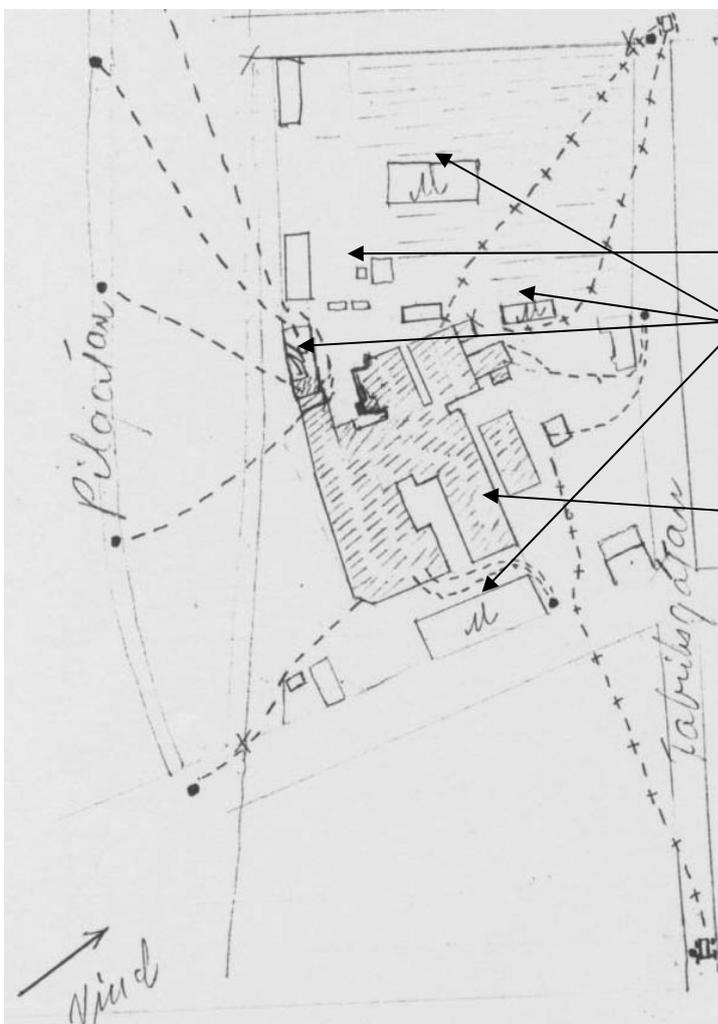
As Sven Jacobsson 9:23 PM started a new round, he saw fire in the splint hall.

The Police and fire protocol verifies fire in a polishing drum at the drying box on the west side of the splint hall. In the newspaper it was said that fire had been seen in a slot of one of the drying boxes, in, or close to, one of the drying boxes in the splint hall. Fire had also been seen from outside coming out of an airshaft over the splint hall roof.



*Appropriate WTF label!*

As the fire alarm was registered at 9:25 PM, the Växjö fire brigade and reserve corps turned out with the tool wagon, after that with the mechanical ladder, and finally with the small and the larger fire steam engines. At 9:28 PM, six firemen with a foreman were in place. Fire Master Zsar expressed his opinion that the fire already was impossible to extinguish or to subdue. The big lathe-hall was on fire.



*The Fire brigade's sketch over the fire at WTF in 1922. (VKA BS DI)*

At 9:40 PM alarm is given to the 40 firemen that are as reserve at the regiment I11, and as it is risk for a large fire, order is given at 10PM to 700 men of the regiment I11's forces to help. The regiment's forces are used to cordon, keep guard, demolition and lay out fire hoses. As a southwest wind threaten the blocks in the city, two men were ordered to protect each yard.

At 10:25 PM, the police began to alarm the 491 men of the public fire brigades by chiming church bells. As the fire reached the northwestern part of the factory, twelve fire hoses of a total length of 2000 m were used to protect the main building, and other buildings,

especially the adjacent warehouses containing matches and chemicals. The Växjö waterworks were pumping at maximum capacity level and delivered 4 m<sup>3</sup>/min.

The cathedral bells accompanied by chemical explosions awoke people, big crowds hastened to the fire site as the fire could be seen and heard far away. Very heavy rains of sparks flew over the city, and burning pieces of wood fell down more than 3 km away.

### WHAT CAUSED THE FIRE AT WEXIÖ MATCH FACTORY.

At 1:00 AM on May 31, the fire was under control, and at 7:00 PM the fire brigade's extinguishing of the fire was finished. The public prosecutor held during the day a police interrogation about the fire. Earlier cases of chemical self-ignition were known and was considered the reason of the fire. The main personnel at WTF and of the fire brigade were asked about observations during the fire and their opinion about the possible reason of the fire. Some evidence pointed at heating of a bearing in the roller, but it could not be proved.

No chemicals that could have caused the fire were to be found. The investigation was closed without finding out the reason for the fire. (VLA FSTF F:6)



*WTF  
splint  
hall  
June 1  
1922  
(photo SM  
WTF).*

In the evening of the 1st of June, at 9:12 PM, the fire alarm sounded again! The fire brigade and the reserve corps turned out with the mechanical ladder. Amorphous phosphorus stored in a cellar had ignited. During removal at the big fire the day before, tins containing red phosphorus were damaged, leading to spontaneous ignition. The fire was extinguished with a fire hose present in the cellar. (VKA BS DI)

In June 1922, WTF made its monthly factory inventory list for May 1922. (VLA JoV) All raw materials that were destroyed by the fire, or for some other reason should not be recorded seem to be designated "other use". The inventory list takes up: alum, aniline dye, antimony trisulphide, asbestos, sulphore acid byrat, auramin, manganese ore, campeche tree, carbon black, caput mortum, chalk, potassium chlorate, chrome yellow, dextrin, fuchsine, glass

powder, gum arabicum, gum dragant, kieselguhr, lime, paraffin, pedoxin, phosphoric acid, phosphorus, photogene, pumice, quartz, red colour, resin, rhodamin B/G, sulphur, sulphofosfit, sulphuric acid, Glittermalm, tin, zinc plate, zinc white

The manager at WTF, Knut Johansson, noted down all known, all older recipes and all the recipes used at the time of the fire. (FOAK WTF)

The Skandia insurance company paid out SEK1 317 275 for the fire damage (VLA FSTF F:6)

### Chemical investigations

Between 1919 and 1922, the consumption (in kg) of different types of red phosphorus at WTF was as shown in the table below. (VLA JoV EVIIIb)

1919-1922	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
Swedish									516	490	372	376
<b>1920</b>												
English			100	500	400	100		500	450	400	150	
French	250	450	300									
German						230	620				230	420
Swedish	462		80									
<b>1921</b>												
English	50	380	465	355	150							
German	350				200	260	305	315	220	225	280	220
<b>1922</b>												
English *				57	141	-350	-150					
German **	345	230	170	235	-500							

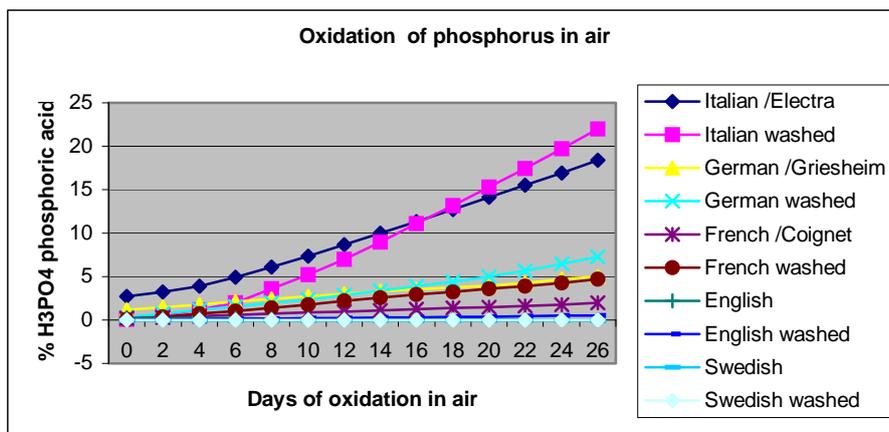
\* -350 kg designated for "other use", \* -150 kg sold to Vetlanda. \*\* -500 kg was returned

On June 13, 1922, STAB's Purchase Department informed about the "German phosphorus order No. 97" from the Chemische Fabrik Griesheim-Elektron in Frankfurt am Main. (VLA JV EJ)

Of 100 tins distributed on March 23 were 51 tins returned May 6 and 30, for investigation in Germany. The acidity – due to oxidised phosphorus – was determined by titration with 0.1 molar sodium hydroxide. In 33 tins the acidity varied between 1.1 - 3.5 ml 0.1 M NaOH / gram.

On June 16, 1922, it was urgently required that tins containing inferior phosphorus should be hermetically sealed by soldering and stored separately.

On June 28, 1922, was in "Circular 35" the Griesheim-Elektron report presented about the problems experienced with different types of red phosphorus.



The diagram shows the acidity of various phosphorus brands as a function of air exposure time. In practice their disposition to get acid in relationship with air. The test result is expressed in curves as a specification of the investigated sample. From the curves we conclude that the washed phosphorus oxidise considerably faster than the unwashed.

The investigation show that the Swedish phosphorus had the lowest primary acidity, *i.e.*, the lowest degree oxidation. While the Italian washed, exhibited the highest degree of oxidation.

The investigation left no results about the general quality of the phosphorus, such as as degree of transformation, grain size, ignition, etc. It only dealt with the relative degree of oxidation when kept in and outside package. (VLA JoV EI-502)

On July 25, 1922, STAB's Purchase Department informed about "German phosphorus order No. 409" comprising 5000 kg of phosphorus in boxes of 5 kg that had arrived to Gothenburg. 2000 kg were test-distributed with 500 kg to each: the Uddevalla factory, the JT and JVT in Jönköping, and to the Vulcan factory in Tidaholm.

The factories, were asked to control the phosphorus quality rigorously before use, reported;

Uddevalla	20/7: Every German box is investigated, we will report every remark.
JT	22/7: The batch contents <0,5% acid, we will report after use.
JVT	12/7: Phosphorus is clean enough from acid and of good quality
Vulcan	24/7: Phosphorus contains <u>white phosphorus</u> and take up much more moisture than English phosphorus; we would rather be excused to use the phosphorus in question. (VLA JoV EI-502)

Some WTF correspondence for the year 1922, both before and after the fire, is not found in the archive-files. Missing are also Circular that Torsten Jung in Jönköping had in his confidential "C-file" as Circular: 208, 248, 289, 290, 294, issued between 1923-30. (VLA JoV EVII)

In 1934, JoV Match Co. issued "Circular 357" to all the STAB factories. It deals with an investigation of "Fires when tins with red phosphorus were emptied".

The investigation was undertaken in 1933 after a fire occurred in a red-phosphorus tin in the Kalmar factory. From reports from other factories it was concluded that fire had occurred at many factories, but with long intervals.

Factory	Time	At work with	Fire ignition course	Cause	Remark
Jönköping	1926	Emptying	Phosphorus dust	Bad phosphorus	English
Jönk o Vul	1914	Emptying	Phosphorus dust	Friction	German
Jönk o Vul	1926	Emptying		Friction	English
Kalmar	1933	Emptying	Ignition explosion		German
Lidköping Norra	1931	Opening	Ignition as opened		
Lidköping Södra	Unknown	Unknown	Unknown		
Uddevalla	1929	Emptying		Friction	
Vulcan	Unknown	Opening		Hit against tin	
Västervik	Years ago				

Experience from the factories tells that tins had to be emptied with highest caution, and the emptied tins should be handled with outmost care.

As an unopened tin in Kalmar was investigated, it was found to contain phosphine (phosphorus hydrogen), but no white phosphorus was found. This is known from English phosphorus tins. The phosphorus hydrogen could possibly cause an easier ignition.

The opening rules were changed: A tin opening tool for cutting off the lid should be added to the homogenising mill in the composition room in order to minimise shaking of the tins as they were emptied. The tin opener should be moistened with water before use. The top of the

tin should be cleaned before opening, and moistened. The worker should use leather gloves and a gas mask. When the lid has been removed, the tin should be left open for a maximum of 6 hours before the tin was emptied. (VLA JoV EVII)

### **PHOSPHORUS DISPOSALS “BACK IN THE LIGHT”**

As in 1973 Firemaster Per-Olof Landström at the Nässjö fire brigade turned out with truck No. 8 to the Anneplast wall-paper factory on the site of the old Anneberg match factory, he found the ground in fire. (Nässjö brandkår, 1973 report 164)

During excavation the smell of garlic was perceived, a sure indication of fosfin, that the phosphorus in the old residue selfignited when exposed to the air. (STAB )

In 1911, the production of phosphorus matches ceased at the Anneberg match factory. It has been told that big, empty barrels without lids were pressed down into the wet ground. Phosphorus was then poured through the barrel as through a tube, and sunk in the ground. Finally, sand was shuffled after the waste. (STAB) The phosphorus was disposed of in this way because of the intensity it causes when burned in the boilers and the risk of damaging them.

As in 1995 the county authorities examined the ground and water around the old match factory. The total phosphorus in Svartån stream, was upstream of the factory 0,066 mg/l, downstream 0,17 mg/l. The reason the phosphorus leakage were not found. (Jönköping county)

#### ***Possible disposal of phosphorus from WTF***

In February 2001, an environmental jurist told me about a person, who between 1940s and 1960s had seen how, after a heavy rainfall, white smoke came up from the ground where once the Växjö pond was situated. This is an obvious indication that the ground holds white phosphorus. As the ground was to be excavated, the authorities in Växjö were informed of this fact, but no environmental investigation of the site was undertaken.

#### ***Excavation of the old Wexjö pond.***

The contractors of the enlarged library building never excavated the ground on the told suspicious points. Only a higher value of phosphorus was registered in the groundwater during excavating.



*The Växjö library  
in 2001.*

### ***Present status***

The disposed waste from the match factories were long forgotten when present days' environment inventories are made; the disposal activities were finished a century ago. Today old match factory sites could be affected by match, sites that today are situated in town centres.

The Swedish phosphorus decree of 1870 stipulated that phosphorus waste should be burnt.

In the production, white-phosphorus waste was kept in buckets and covered with water. These buckets were as a rule emptied in marshy ground, because burning in the boilers was too intense and the risk of boiler damage high

Water from the washing and cleaning of the phosphorus working rooms, which was made every two weeks, should be thrown in a deep, separate well (Swe: Brännrop, i.e.. fire pit). Was there water in these wells or not when they were used? If there was, the white phosphorus in the discarded composition can be kept anaerobically in the bottom sediments for a very long time. (FOA-Rapport-00-01569-222)

If there was no water furthering an anaerobic condition, the white phosphorus was slowly oxidised in contact with air.

Information about the waste is in the archives. After finding out the details of the individual disposal system used and their present conditions, environmental remediation actions can start.

### ***WTF waste statistics based on 1891 match recipies***

The 1870 phosphorus decree stipulated how to handle waste and water from the factories.

Between 1868 and 1913, WTF consumed approximately 85 tons of white phosphorus.

In the 19th century, the groundwater level at the site for WTF was such that a deep wash water well, if and wherever it was situated, must have contained groundwater. Assuming that 0.5 % of the white phosphorus was thrown out with the wash water, the ground where WTF's wash water well is situated could hold 400 kg P<sub>4</sub>. If we assume that 3% white phosphorus was disposed, the Växjö ground could hold as much as 2.5 tons P<sub>4</sub>.

In 1913, when WTF discontinued its production of phosphorus matches, a disposal of the remaining white phosphorus could have been made. In 1922, red phosphorus tins turned out to be contaminated with white phosphorus. After the fire at Wexjö Match Factory (WTF) 1922, red phosphorus tins self-ignited after been damaged under removal during the fire. According to available factory statistics, we are probably dealing with 70 tins of 5 kg each.

If we assume that this is the secret transport made in the 1920's, 350 kg of white phosphorus-contaminated red phosphorus could have been disposed in the marshy ground in the east part of the Kronoberg county.

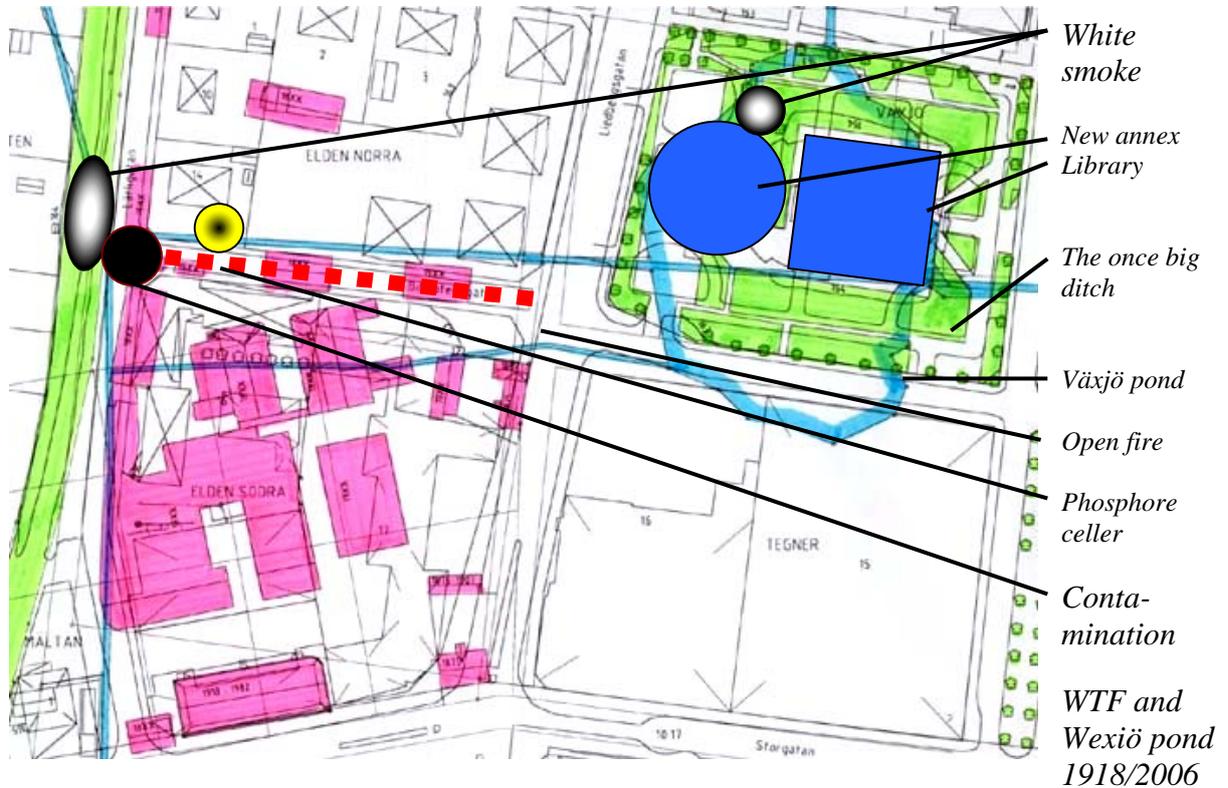
In the 1920's and 30's, red phosphorus tins have self-ignited as they were opened, or afterwards, and caused unexplainable fires at Swedish match factories. Investigations made found phosphine in such tins. This poisonous gas might have facilitated the ignition.

### ***The environment***

It is difficult to judge, identify and estimate possible environmental consequences. It is imperative to look through the archives for information. The suspected areas should be investigated with modern techniques, and cleaned. It is vital to ensure that the suspected sites and transported materials won't be harmful to people or the environment now or in future.

Recently I found an excavator digging a 3 m deep pit in Lärkgatan, where the Wexjö Match Factory (WTF) once was located. As digging, a white cloud came up from the ground enclosing the excavator, smelling strongly. Going down into the pit, the workers found the ground full of white-gray nearly burning ground material.

The workers led me to find a person that 1983 worked with excavation of the roads in the same area. Several phosphorus fires had then started when it was digged in Biblioteksgatan. The crossing of Biblioteksgatan and Lärkgatan is a waste disposal site.



The Wexjö Match Factory (WTF) story is not yet finished, the last chapter will be written as on the other places where phosphorus has been handled in the past.