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Category F:
Special Projects

Photocatalytic Gas Treatment (PGT)

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Canadian patent: 2,527,450
US patent: 7,304,187

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2-PAGE PROJECT HIGHLIGHTS

Photocatalytic Gas Treatment (PGT)

Category F: Special Projects

The project

For the new wood panel manufacturing plant it was planning to open in Moncure, North Carolina, Uniboard Pfleiderer asked **exp** to come up with a new process to treat the gases produced by the future plant's pressing and drying operations. Traditional methods used in the industry to oxidize and destroy the polluting volatile organic compounds (VOCs) were not viable options for our client, either due to space, operational and temperature considerations or because they were too costly and harmful to the environment.

Exp was recommended to the German-based parent company after our firm developed an innovative process for two Uniboard plants in Quebec to effectively oxidize a single polluting compound – formaldehyde – via catalysis using oxygenated water.

The new process would have to destroy several different types of VOCs as well as meet the State of North Carolina's and the EPA's very stringent environmental standards. Many unsuccessful attempts had been made in the past, and no other technology had been invented in over 30 years to address this kind of issue and adequately fulfill society's new expectations for sustainable development.

With a very short timeframe to deliver the new process, this was a major technological challenge. At the time, the team never would have expected that it would ultimately lead to a groundbreaking innovation for the global industry.

New application of existing techniques, leading to global innovation

The technology developed by **exp**, called "Photocatalytic Gas Treatment" (PGT), is unique in the world and is now patented or has patents pending in 39 countries. It is a global first in advanced oxidation, where hydrogen peroxide is used as the oxidizing agent, on an industrial scale, to dynamically treat polluting gases. In addition, the use of ultraviolet lamps to regenerate the stabilized catalyst, combined with hydrogen peroxide, represents one of the most groundbreaking and economical ways to oxidize polluting, water-soluble, organic compounds such as alcohols, aldehydes, phenolic compounds, etc.

The EPA is carefully analyzing this new technology because it might replace thermal destruction technology that, simply put, is efficient but expensive and, more importantly, generates a significant quantity of greenhouse gases due to the fossil-based combustion used to produce heat. In addition, **exp** was invited to Brussels this spring to present PGT technology to the European Union's committee for the recognition of new and innovative technology (BAT: Best Available Technology) in environmental matters.

This technology is original because, in addition to being compact, cost-effective and non-polluting, it uses only the energy necessary to destroy polluting organic compounds in industrial gas emissions and does not generate additional greenhouse gases.

Thus, Uniboard Pfleiderer was the first company in the United States to use PGT technology engineered in Canada. The technology allowed the company to cost-effectively meet EPA standards. Following this success, interest in the technology in the United State has grown and over 22 licensing modification requests have been submitted to the EPA by hardboard factories wishing to use PGT technology.

Complexity

The complexity of the new PGT technology stemmed mainly from the development of a technology that would be in line with society's new sustainability values. To meet all of the criteria – including US standards, cost-effectiveness and space restrictions – **exp** determined that an advanced oxidation technology using hydrogen peroxide could help achieve these goals. Exp then developed the catalysts required for advanced oxidation, which in turn needed a source of energy to be reactivated. The method chosen to keep the catalysts active in the reaction water was energetic photons. Ultraviolet lamps were therefore used for photon production, although sourcing these lamps and calculating their power requirements proved to be difficult, since none had ever been manufactured for this type of large-scale industrial application.

There was also the additional challenge of implementing the technology in the short time allotted, including the very complex task of scaling the technology – from the lab to the pilot plant, and from the pilot plant to two different production treatment units.

Environmental Impact

An environmentally-friendly technology, PGT uses hydrogen peroxide (oxygenated water) as an oxidizing agent. In the presence of stabilized catalysts, the hydrogen peroxide generates an OH radical that reacts thoroughly with organic pollutants, reducing them to carbon gas. Extremely effective, this catalyzed reaction requires a very low concentration of hydrogen peroxide in the water to be efficient. In addition, the catalysts developed by exp contain no noble or heavy metals and are biodegradable. As water is a precious natural resource, PGT was designed to operate in a quasi-closed loop so that 99.99% of the water is constantly reused.

This new technology reduces the factory's carbon emissions by more than 80,000 tons per year.

Official tests conducted in October 2011 determined that the two systems (drying and pressing) met North Carolina standards, allowing Uniboard to reduce the total production of harmful VOCs to levels under the permitted maximum limits. In addition, the PGT systems complied with the EPA's MACT standards by achieving an over 90% reduction in formaldehyde and methanol.

Social and economic benefits

In addition to surpassing the project's environmental goals, the new technology also provides a number of social and economic benefits, such as: (a) a clean air environment inside the factory to ensure health and safety of workers; (b) having an impact on manufacturing worldwide by offering a simpler, more cost-effective and greener alternative to outdated technologies; (c) promoting Canadian know-how and engineering to other countries.

Meeting the client's needs

The project, which began with R&D to create an innovative gas treatment and ended with the official recording of positive results, was delivered in a very aggressive timeframe. Research had to be completed in 16 weeks – from early August to late November 2008 – so that pilot testing could begin in early January 2009. Design engineering was initiated shortly after the beginning of the pilot tests to feed design details to the construction site. For this project, the engineering, the system's on-site construction and the shop production of major parts were occurring almost simultaneously.

In June 2010, the first PGT unit in history received the first gases for treatment and the reaction functioned as planned. The two PGT units were officially tested in October 2011 to evaluate their performance with regards to the destruction of methanol and formaldehyde. The results were conclusive – both installed systems would allow the client to meet the EPA's and the State of North Carolina's regulations. A resounding success!

FULL PROJECT DESCRIPTION

Photocatalytic Gas Treatment (PGT)
Category F: Special Projects

Canadian patent: 2,527,450
US patent : 7,304,187

Executive summary

In 2008, we were approached by Uniboard's Pfleiderer plants to invent a new way of oxidizing and destroying certain volatile organic compounds (VOCs).

Emission standards vary throughout the world. Volatile organic compounds (VOCs) are substances composed of at least one carbon atom and one hydrogen atom. They are found in the gaseous state in the atmosphere. Many of these compounds contribute to the photochemical reactions responsible for the formation of tropospheric ozone. Others, such as methane and formaldehyde, are also considered toxic and can have a negative impact on health and the environment.

The German-based parent company wished to open a new wood panel manufacturing plant in North Carolina, in the US. This innovation project was driven by the company's desire to reduce the important costs associated with using natural gas in standard VOC destruction processes, as well as the large quantities of greenhouse gases and NOx that these produce.

Following our R&D work, a new photocatalyzing oxidation process (PGT) was invented in our research laboratories. Pilot testing conducted in the US confirmed our initial results.

The client gave its approval for the preliminary and detail engineering of two photocatalytic gas treatment (PGT) units, valued at over $14 million, for its future plant in Moncure, NC. **Exp** provided R&D, pilot testing, preliminary and detail engineering and commissioning services for a total fee of slightly more than $2.6 million, or 18% of the project's cost, excluding monitoring.

In November 2011, the results surpassed the client's expectations with a destruction rate of approximately 94%, easily meeting the standards set out by the US Environmental Protection Agency (EPA). A new world-class Canadian invention was born and was slated to make an impact on the manufacturing industry.

In addition to all of the benefits related to the successful project, few people, and even fewer professionals will ever have the privilege or opportunity to be part of such a groundbreaking technological innovation. These events will forever mark the professional, personal and family lives of everyone on our team, junior, intermediate and senior professionals alike.

New application of existing techniques, leading to global innovation

In 2003, our engineering team was selected by the Uniboard plant in Mont-Laurier, in Quebec, to study the different available technologies to address formaldehyde emissions. The source of emission was a wood panel press with a gas flow of 70,000 m^3/h and 22 ppm of formaldehyde. The first widely-known technology uses bacteria to oxidize formaldehyde. However, due to space, operational and gas temperature considerations, this technique was not an option for the plant. The other technology that has been used for several decades consists in directing the contaminated gas over ceramic tiles heated to very high temperatures. The volatile organic compounds (VOCs), including formaldehyde, are thereby oxidized to CO and CO_2. However, this technology was found to be very expensive for the plant – with propane costs estimated at $2 million/year– and environmentally harmful because of the large quantities of greenhouse gas emissions and NOx produced. Unfortunately, since no other technology was available, the only possible choice was thermal destruction. The major investment was delayed due to financial constraints.

Meanwhile, another Quebec Uniboard plant located in the town of Sayabec, was grappling with the same environmental and employee health and safety concerns. The gases emitted by their press were not being evacuated, creating a difficult work environment. The same conclusions were presented to the plant's management, but in this case, the emission rate was 80,000 m^3/h, with formaldehyde concentrations reaching 77 ppm. Since no existing solution was financially or technically feasible for either of these two plants, we suggested trying to oxidize the formaldehyde via catalysis using oxygenated water.

When pilot tests showed positive results with a formaldehyde destruction rate of over 90%, we proceeded to design and build three formaldehyde treatment units for these plants in 2004, 2005 and 2006. This newly developed process was limited to the oxidation of formaldehyde molecules.

Following the surprising success of this endeavor, Uniboard Canada strongly recommended us to the company's German parent organization – Pfleiderer – to develop a new process that would help the company meet US government standards for the new panel manufacturing plant it planned to build. At the time, we never would have expected that the initial mandate we were given would ultimately lead to a groundbreaking innovation for the global industry.

Identifying the project and the environmental challenge

Having already developed and created a process to effectively oxidize a CH_2O organic molecule (regulated in Quebec) for panel manufacturing plants, it was easy for us to grasp the environmental issues at hand. While our relevant expertise and experience with emissions in Quebec were definite assets, the German company's expectations for its planned US facilities were not easy to meet, given the timeframe and the State of North Carolina's and the EPA's very stringent environmental standards .

Emissions from the future plant's kiln and press needed to meet the EPA's Maximum Achievable Control Technology (MACT) standards, which include six conditions, and the State of North Carolina's PSD regulations concerning total VOC contributions. The German and American executives also wanted the process to destroy several soluble volatile organic compounds (VOCs), including aldehydes and alcohols, or, more specifically, formaldehyde (CH_2O) and methanol (MeOH). While this represented a major technological challenge, it was also stimulating and of potentially global significance. Many unsuccessful attempts had been made in the past, and no other technology had been invented in over 30 years to address this kind of issue and adequately fulfill society's new expectations for sustainable development.

Defining the project and innovation

Based on our technical knowledge of formaldehyde oxidation in the Canadian context, we were able to establish premises to meet the expectations of our European client and those of the US federal and State governments with respect to the destruction of volatile organic molecules.

After having conducted several meetings and based on all of these considerations, we developed and presented an R&D plan to all the parties involved. The program accurately identified the issue, the sources of technical solutions and the potential innovation. Further to a series of changes to the master plan, the R&D innovation program was approved despite a relatively low probability of success, which was, at the time, estimated at less than 10%. However, the high cost of using natural gas (approximately $3 million/year) for the only suitable technology available supported this decision. The cost of the R&D program, then evaluated at $600,000, was shared equally between the plant and **exp** to reduce the risks while further stimulating our team.

Performance and implementation phases

The invention of a new environmental technology of this scale involves a high level of complexity and must be carried out in phases. Because **exp** owns numerous Canadian facilities, mobile units and equipment unique in Canada and even North America, our firm has the ability to deliver complete consulting engineering solutions, from the initial concept right through to production. In this specific project, all phases were handled by **exp**.

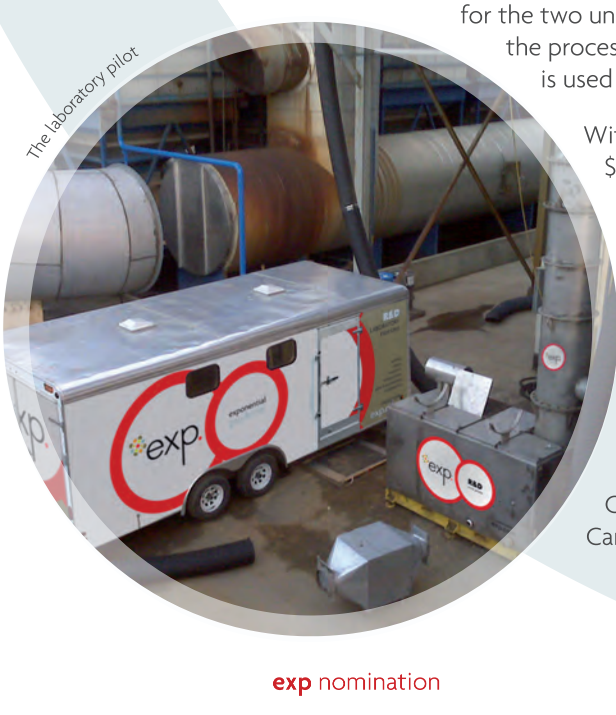
1.1 R&D program

Using our own inorganic, organic and analysis laboratories, we performed tests on simulation matrices containing standard levels of aldehyde and alcohol VOCs. Unconfined tests demonstrated the feasibility of oxidizing the two targeted molecules via homogenous photocatalytic treatment. Following repeatedly successful tests, we developed a closed-loop pilot of this process in our laboratory. Then, after several weeks of laboratory pilot testing, we successfully determined the operating parameters of the new photocatalytic gas treatment – or PGT – process, which would one day hopefully solve a major problem in the manufacturing industry.

1.2 Preliminary engineering

The laboratory pilot tests continued day and night, in successive 12-hour shifts, to collect the necessary data for a preliminary estimation of the operating and construction costs of the two gas treatment units. Despite the laboratory pilot's small size, we were able to establish an overall budget of $12 million for the two units and annual operating costs of under half a million dollars. Furthermore, the process would produce no emissions of CO, CO_2, NOx, etc., as oxygenated water is used for oxidation, reducing them to mineral elements.

With the probability of success estimated at 50%, engineering budgets totaling $1.2 million were allocated and Go/No-Go criteria were dependent on the plant pilot tests, for which an additional budget of $400,000 had been approved.



The laboratory pilot

1.3 Plant pilot testing and detail engineering

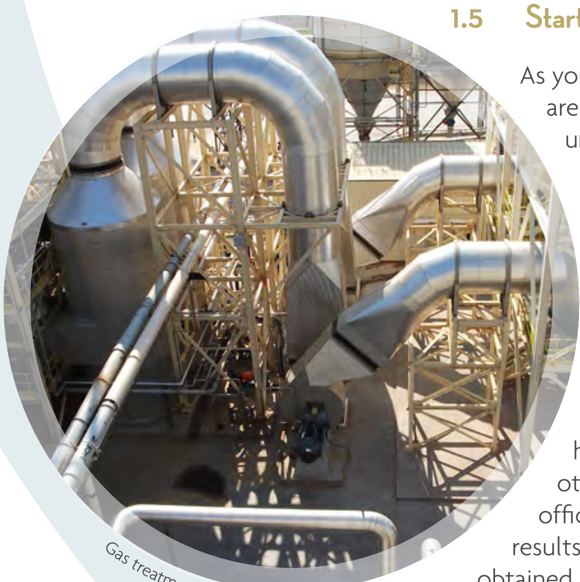
Since the window for the implementation of the competing technology was getting smaller in the event that our new technology failed, it was decided to perform pilot testing concurrently with the detail engineering. **Exp**'s plant pilot unit and mobile laboratory were sent to a plant in North Carolina. The engineering and design team from the Quebec City office in Canada worked closely with the team at the US site. Problems related to the generation of photons, needed to activate the catalysts that create the powerful oxidant from oxygenated water, disrupted the achievement of testing and detail engineering milestones.

The tests performed at the plant pilot, at a gas flow rate of 2,000 m^3/h, allowed us to confirm the required design criteria for the detail engineering. With confidence in the new process's success now estimated at more than 80%, all required construction budgets were approved and calls for tenders, including plans and specifications in all disciplines, were issued.

1.4 Construction monitoring and pre-operational checks

To increase delivery efficiency, construction monitoring was contracted out to a local engineering firm in North Carolina, whose mandate was to ensure that our construction plans and specifications were being followed. The American engineers were in constant contact with our designers in Quebec City, collaborating adequately despite the cultural and linguistic differences. Pre-operational testing of the new process was performed by our chemical, mechanical, electrical and automation engineers and technicians. This part of the project needed to be completed by our own designers due to the highly confidential nature of this new and promising process, for which patents were pending.

1.5 Start-up and impressive results


Gas treatment units

As you can visually see, we developed two very large **gas treatment units**, which are rated at 62,000 m^3/h and 427,000 m^3/h, respectively. The start-up of the units was acceptable. However, the plant's management and staff were very busy with the start-up of the panel production lines. Because employees were tied up with start-up problems occurring at the manufacturing plant, their training was delayed and the operation of the two treatment units was not taken over by local staff as quickly as originally planned. In addition, global management of the $160 million plant construction project was given to a Swiss consulting engineering firm, adding to the confusion.

To meet the global construction budget, the Swiss firm only purchased half of our photonic needs to initiate the catalytic reaction. After the other section (50%) was installed in October 2011, the plant performed official sampling on both treatment units with our technical assistance. The results were impressive, perfectly matching our expectations and the R&D results obtained in 2008 and 2009.

Complexity

The complexity of the new PGT technology stemmed mainly from the development of a technology that would be in line with society's new sustainability values. There was also the additional challenge of implementing the technology and completing the industrial scaling in the short time alloted.

Photocatalytic Gas Treatment (PGT)

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Consequently, the mandate given to **exp** by Uniboard Pfleiderer was both considerable and daunting – developing an innovative technology that could comply with the efficiency criteria set out by the US regulatory authorities; take into account financial restrictions (project capitalization, annual operating and maintenance costs); and meet the physical constraints of a limited footprint.

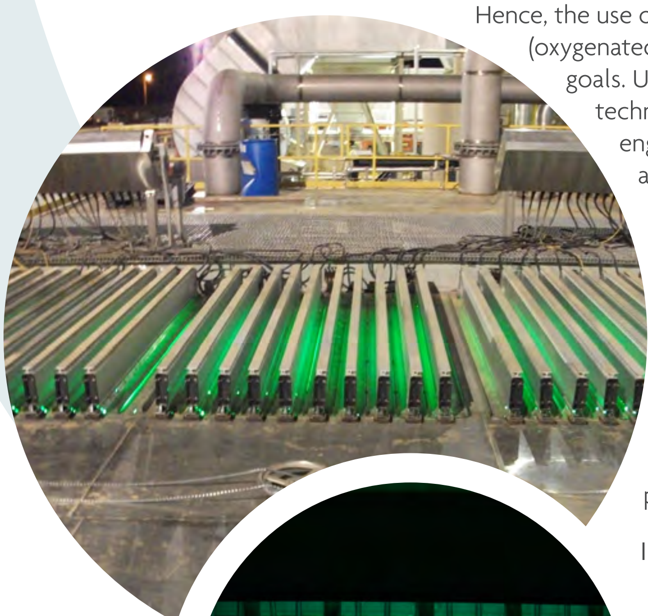
The technology's efficiency was dictated by the EPA's MACT standards, which require US wood panel manufacturers to destroy 90% of their methanol and formaldehyde emissions from kilns and presses before end-of-pipe. Given the fact that in this industry, the pollutants (methanol, formaldehyde, phenol, etc.) are found in highly diluted states (from 10 to 100 ppm in the air) in very elevated airflows (50,000 to 450,000 m^3/h), most technologies are ineffective in this sector or very expensive. The new PGT technology therefore needed to combine the recognized effectiveness of technologies that use thermal destruction (VOC destruction rate of over 90% but with a high operating cost) and the low cost associated with biological processes (lesser effectiveness and larger footprint).

To achieve this, **exp** set three goals for the development of the new technology:

- First, the technology's operating cost would have to be independent of the gas flow, determined instead by the quantity of pollutants to be destroyed per unit of time.
- Second, the pollutants would need to be oxidized using an environmentally friendly compound.
- Lastly, the technology would need to be compact.

Hence, the use of advanced oxidation technology using hydrogen peroxide (oxygenated water) as an oxidizing agent could help us achieve these three goals. Used alone, hydrogen peroxide is ineffective in this type of technology. **Exp**'s team of process experts (chemists and chemical engineers) therefore needed to develop the catalysts required for advanced oxidation. Following intensive R&D work in **exp**'s laboratory, the team successfully developed a stabilized catalysts able to produce, in the laboratory, the OH radicals needed to oxidize the organic matter from hydrogen peroxide. The catalysts needed a source of energy to be reactivated, so that they could continue to produce OH radicals from hydrogen peroxide. The method chosen to keep the catalysts active in the reaction water was energetic photons. Ultraviolet lamps were therefore used for photon production. The advanced oxidation technology that could purify industrial gases was born: **the Photocatalytic Gas Treatment (PGT)** process.

In addition to the technical complexity of the project, the schedule to complete the work was very ambitious. The R&D, pilot scaling and implementation of the two industrial treatment units had to be completed in less than a year in order to give Uniboard time to operate the new systems for a few months prior to commissioning. This lead time was necessary so that any required operating parameter adjustments could be made to meet the EPA's new regulatory standards prior to their coming into force in October 2011.



Ultraviolet photocatalysis in the reactor

Considering the short timeframe that **exp**'s team had to deliver the project, another factor that increased complexity was scaling, which needed to be done in two stages. The first scaling was from the laboratory to the industrial pilot unit. In the laboratory, tests were performed on a gas flow to be treated of 0.1 m^3/h, whereas the pilot unit's gas flow was 2,000 m^3/h, representing a scale factor of 20,000. This scaling was essential to obtain valid design data for the two industrial units. During testing, two separate teams worked concurrently to deliver the project on time. A process team (chemical engineers, chemical technicians and chemists) performed the industrial pilot tests to collect critical design data, while an engineering design team (electrical, chemical, mechanical and structural engineers) focused on producing the plans needed to start construction.

The system's design was extremely complex, as the scaling of this unique and innovative process was being done for two different treatment units. The larger unit was rated at 427,000 m^3/h for the treatment of gases emitted by the kiln, i.e. 215 times greater than the plant pilot unit. Calculating the power requirements for the ultraviolet lamps in this design proved to be difficult, as **exp'**s team needed to extrapolate those requirements based on the pilot unit's lamps, which did not have the same intensity as the industrial lamps. Furthermore, we received very little support from the lamp supplier, who neither understood nor believed in our technology. Lastly, the operating temperatures of the PGT were much higher than the normal operating temperatures in the UV water treatment applications for which the lamps were approved. In this new industrial process, over 800 industrial lamps would be needed for the kiln's unit and over 240 lamps for the press' unit, which automatically eliminated smaller lamp manufacturers. **Exp** therefore had to negotiate with a single supplier capable of filling an order of that size along with control modules, all by the required date.

Environmental impacts

Integration of sustainable development

For several years, the scientific community has attempted to reduce to a minimum the risks of exposure to hazards associated with the chemical industry's activities, by monitoring toxic substances at every process phase: storage, use, treatment and disposal.

From the outset, and by using a catalytic solution with minimal reagents, cutting edge technology rooted in sustainable development principles based on the premises of green chemistry[1] guided the development of a new design. Furthermore, the design required that no by-products hazardous to the environment be generated by the reagent used.

Economic aspects

This technology is currently one of the most economic, fuel-efficient technologies available. As it is more effective and less costly than traditional technologies, we can confirm that the new technology's economic impacts will be positive, ensuring its viability for the company while respecting high standards. In addition, by making use of this new technology that reduces the factory's carbon emissions by more than 80,000 tons per year, Uniboard Pfleiderer may be eligible for carbon credits.

Environmental aspects

The technology developed uses hydrogen peroxide, made from oxygenated water, as an oxidizing agent. In the presence of stabilized catalysts, the hydrogen peroxide generates an OH radical that reacts

[1] The aim of green chemistry is to design chemical products and processes that reduce or eliminate the use and synthesis of hazardous substances. — Definition of the American Environmental Protection Agency (EPA), 1991.

Photocatalytic Gas Treatment (PGT)

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Absorption towers at plant in Moncure, North Carolina

thoroughly with organic pollutants, reducing them to carbon gas. Extremely effective, this catalyzed reaction requires a very low concentration of hydrogen peroxide in the water to be efficient. Indeed, a concentration of only 500 ppm of hydrogen peroxide is required to ensure that the reaction works, i.e., a concentration 60 times lower than that found in hydrogen peroxide sold at the pharmacy. In addition, the catalysts developed by **exp** contains no noble or heavy metals and, what's more, are biodegradable.

As water is a precious natural resource, PGT was designed to operate in a quasi-closed loop. Indeed, 99.99% of the water is constantly reused since the reaction allows for the elimination of all incoming pollutants. Salts that might enter through gas emissions produced by the kiln or the press are kept at a low level by simply flushing the reactor with water. The flush contains the biodegradable catalysts (30 ppm), hydrogen peroxide that decomposes to water and oxygen when it leaves the system, and some highly diluted salts similar in composition to the salts found in the wood used in board production.

Social aspects, well-being and safety

PGT functions in a highly diluted medium (99% water), thus eliminating the risk of serious injury for workers in contact with water from the process. If maintenance is required, the oxidation reaction may be terminated quickly (in less than 30 seconds) by simply shutting off the ultraviolet lamps that power the reaction.

In addition to the positive environmental impacts previously mentioned, we should mention that, since the technology destroys volatile organic compounds, air quality can only be improved. Also, the elimination of these gases in the air ensures the health and security of factory workers. The positive social impact for workers and the community is obvious.

Original solutions

The technology developed by **exp** is unique in the world and is now patented or has patents pending in 39 countries. This is a global first in advanced oxidation in which hydrogen peroxide is used as the oxidizing agent, on an industrial scale, to dynamically treat polluting gases. In addition, the use of ultraviolet lamps to regenerate the stabilized catalysts, combined with hydrogen peroxide, represents one of the most groundbreaking and economical ways to oxidize polluting, water-soluble, organic compounds such as alcohols, aldehydes, phenolic compounds, etc. At this very moment, the EPA is carefully analyzing this new technology because it might replace thermal destruction technology that, simply put, is efficient but expensive and, more importantly, generates a significant quantity of greenhouse gases due to the fossil-based combustion used to produce heat. In addition, **exp** was invited to Brussels this spring to present PGT technology to the **European Union**'s committee for the recognition of new and innovative technology (**BAT: Best Available Technology**) in environmental matters.

This technology is original because, in addition to being compact, cost-effective and non-polluting, it uses only the energy necessary to destroy polluting organic compounds in industrial gas emissions and does not generate additional greenhouse gases.

Thus, Uniboard Pfleiderer was the first company in the United States to use PGT technology engineered in Canada. The technology allowed the company to cost-effectively meet EPA standards. Following this success, interest in the technology in the United State has grown and over 22 licensing modification requests have been submitted to the EPA by hardboard factories wishing to use PGT technology.

Functionality

The engineering design team contributed to the implementation of a gas treatment system for which the hydraulic conditions might be adjusted easily. Indeed, given the importance of the scale and the uniqueness of the process, the start-up team had to have a flexible system. Thus, the recirculation flows in the absorption towers and under the lamps, the filtration rate in the reaction environment and the water levels in the reactor could be adjusted easily.

Well-designed engineering facilitated the implementation of the gas treatment system, thanks to the wide range of adjustments available to operators. Furthermore, the lack of observable blockages to recirculation flows, calculated to ensure a high absorption of pollutants, demonstrated the quality of the absorption tower design.

When official tests were conducted in October 2011, **exp** and Uniboard were proud to announce that all the engineering had been executed according to established practices and that the two systems (drying and pressing) met North Carolina standards, allowing Uniboard to reduce the total production of VOCs to levels under the permitted maximum limits. In addition, the PGT systems complied with the EPA's MACT standards by achieving an over 90% reduction in formaldehyde and methanol. In fact, the official results of the three gas samples taken by a recognized and certified firm demonstrated that the PGT treatment allowed for the reduction of **94% of the formaldehyde and 93% of the methanol** contained in gases produced by the kiln, as well as **94% and 96% respectively for formaldehyde and methanol** contained in gases emitted by the press. A resounding success for a world premiere.

Social and economic benefits

Selection of resources

The realization of this innovative project allowed **exp** to propose and put into action its team comprised of professionals from the pure sciences (chemists, biochemists) and applied sciences (mechanical, structural, electrical, instrumentation and chemical engineers). The knowledge and expertise of all of these multidisciplinary resources allowed for the realization of this project's full cycle in order to fully integrate the idea (see the cycle on the next page). With solid experience in a variety of complex and similar projects, **exp** already had the highly-qualified staff on hand to ensure the success of this project.

Indeed, the same personnel perfected a Catalytic Gas Treatment (CGT). Working together for ten years has allowed us to identify the strengths and qualities of each member of our team, making it efficient and able to tackle the American environmental challenge.

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Mobilization and motivation for this "Labor of Love"

It was extremely easy to mobilize the entire team and to keep motivation high over the last three years. Among the most stimulating elements, we should mention the following:

- Inventing a new, clean technology, **without greenhouse gas and without NOx**.
- Maintaining a clean air environment inside the factory to ensure **health and safety of workers**.
- Obtaining **simple and cost-effective** VOC oxidation without using a combustible fossil fuel such as natural gas.
- Destroying over 90% of the alcohols and aldehydes hazardous to all living things.
- **Competing with outdated German and American technologies** to oxidize VOCs for the whole planet.
- Promoting **Canadian know-how and engineering** to Europeans and Americans.

Most of all, however, enjoying the satisfaction of having participated in the discovery of the «PGT» process that has become one of the greatest Canadian inventions of the last ten years and is having an impact on manufacturing worldwide.

The whole team, in collaboration with the client, participated in daily, weekly and, sometimes, special meetings in order to track the evolution of this innovative project. Every Thursday at informal «happy hours» held in our offices and R&D labs, 20 to 30 staff members met to share recent developments or discuss the latest and greatest technological breakthroughs.

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Congratulations to the whole team!

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Sébastien Côté

SHARED SERVICES

Secretarial and administrative

Serge Gendron
Sylvie Tremblay
Nathalie Saez
Ysabel Milot

Patents and legal

Josée Gagnon
Eve-Stéphanie Sauvé
Keith Flavell
David St-Martin

PGT - night view

The engineers and technicians at Midsouth Engineering in North Carolina.

As well as our client Uniboard Pfleiderer for its tremendous confidence and unflagging support, in particular, Mr. James Hogg, CEO; Mr. Pierre-André Gignac, Eng., Director, Environment, Health & Safety, Quality; and Mr. Alain Barbe, Director, Special Projects.

Photocatalytic Gas Treatment (PGT)

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Impact on the profession

Few technologies are available to destroy pollutants in industrial gas emissions. Those that exist are either damaging to the ozone layer, or have many limitations.

When we were called upon to solve an air emission issue for a plant in the particle board manufacturing industry, our options were limited. Nevertheless, our firm was willing and able to rise to this major challenge.

From the start, we suggested using a scientific approach to resolve the issue and following up with on-site pilot testing to verify the science. Our client considered that, while unorthodox, this solution tailored to its specific needs was very interesting. Very few firms are able to provide, under a single roof, engineering services that combine pure and applied sciences. Our multidisciplinary teams of engineers (mechanical, chemical, electrical and structural) and chemists, working out of our own research laboratories, are able to work hand in hand to find, develop and implement new technologies.

Recent developments in this new technology for destroying pollutants in air emissions have allowed it to penetrate the American market, thereby opening a new door through which Canadian engineering can be exported and used throughout the world. With the globalization of markets, we've had access to products from around the world for a number of years now. However, countries will soon be faced with the challenge of complying with the same environmental standards for their manufacturing practices, which means they will be pressured to offer a clean and inexpensive gas destruction technology like the one we have developed.

In fact, we have been invited by the European Union to present our technology at a special meeting in Brussels. In addition, 27 preliminary studies are under way (22 in the US and 5 in Europe) to replace technologies in those countries that are not compatible with the concept of sustainability. The potential economic benefits to Canada are significant – each unit costs between $4 million and $8 million, the royalty is approximately $100,000 ($1 US/SCFM), and operating license fees are approximately $70,000/year for 20 years.

Given on-going pressures from large industrialized countries to protect the environment and reduce greenhouse gases, we firmly believe that this new technology is bound to play a major role on a global scale. Once again, this will place Canada at the forefront of this niche.

In addition to all of the benefits related to this successful project, few people, and even fewer professionals will ever have the privilege or opportunity to participate in such groundbreaking technological innovations. These events will forever mark the professional, personal and family lives of everyone on our team, junior, intermediate and senior professionals alike.

Meeting the client's needs

Budget

The gas treatment project began with **exp**'s process team doing very intensive R&D and pilot testing work, at a cost of $1.2 million, shared equally. Implementing the two Photocatalytic Gas Treatment units of 427,000 m^3/h and 62,000 m^3/h was completed at a global cost of $12 million. In addition, the cost of preliminary and detail engineering was $1.1 million, and technical assistance services at start-up and compliance testing were $350,000. The total cost of the gas treatment project, including the PGT units for the kiln and the press, was $14.6 million.

Schedule

The project, which began with R&D to create an innovative gas treatment and ended with the official recording of positive results, was delivered in a very aggressive timeframe. Research had to be completed in 16 weeks – from early August to late November 2008 – so that pilot testing could begin in early January 2009. To achieve this impossible goal, **exp** had to work around the clock. Mission accomplished! By the last week of November, the PGT technology was functioning in our laboratory, using a dynamic model that mirrored the industrial setting.

This cleared the way for the next phase, which was to conduct pilot testing on industrial gases. In January 2009, the CGT pilot unit (first generation alkaline version of the PGT) was retrofitted with the ultraviolet lamps needed for the reaction, and shipped to Moncure, NC, so that pilot testing could be performed at the particle board plant. Although the PGT project was meant for the client's MDF production facilities, that plant was under construction at the time of the pilot tests. The pilot tests were performed from January to May 2009. Design engineering was initiated shortly after the beginning of the pilot tests to feed design details to the construction site in Moncure. Design engineering therefore began in January 2009 and ended in September 2009. The schedule was very tight, and the bottleneck was not at the engineering design phase but at the pilot testing phase, which provided the necessary data, day by day. For this project, the engineering, the system's on-site construction and the shop production of major parts were occurring almost simultaneously.

At the beginning of June 2010, **the first PGT unit in history** was ready for start-up, i.e. the unit intended to treat gas emissions from the plant's kiln. The second PGT unit intended to treat gases from the press was 75% completed. This was a success: in mid-June, the PGT received the first gases for treatment and the reaction was functioning according to the criteria defined in the pilot tests and the theory outlined in the documentation and the numerous laboratory test results.

Initially and for several months, the PGT was operated by the **exp** team that had performed the pilot tests, to help ease the workload of Uniboard's operators, who had to focus on starting up the new MDF line.

In October 2010, designated Uniboard operators were trained by exp's employees to properly operate the PGT to achieve gas treatment levels that complied with MACT standards. Following a few preparation tests to make adjustments and add missing lamps, the two PGT units were officially tested in October 2011 to evaluate their performance with regards to the destruction of methanol and formaldehyde. The results were conclusive – both installed systems would allow the client to meet the EPA's and the State of North Carolina's regulations. **A resounding success!**

Conclusion

In conclusion, we would like to quote the words of our client, Pierre-André Gignac, Engineer and Director, Environment, Health & Safety, Quality at Uniboard Pfleiderer:

«This team, which has earned our utmost respect and trust, has an excellent reputation for designing innovative processes. It has successfully delivered a new, effective, inexpensive and simple process that is able to favorably compete with old North American and European technologies. We understand that it is now patented or has a patent pending in over 39 countries. More than 25 projects in the US and Europe are currently in the preliminary design stage or are under way. The EPA is following this technology with interest, since it will be instrumental in significantly reducing greenhouse gases in the US in the future. Meetings are planned in the spring of 2012 with the European Union in Brussels to classify this innovative process as Best Available Technology (BAT).

The discovery of the PGT process is one of Quebec's greatest inventions of the decade that will have an impact on the global manufacturing industry. This is an incredible success by a world-caliber team from Quebec.

Congratulations and thank you to the whole team.»

— Pierre-André Gignac

Panoramic view of the treatment units