



BARRICK GOLD'S

Pueblo Viejo Project

The world's largest autoclaves

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Introduction/Summary

This is the story of an engineering challenge for the ages: Barrick Gold's gold mine development in the Dominican Republic.

The same mine was played out by the Spaniards in the 16th century, and again by a government-owned mining company in the 1990's. New technologies have again made it possible to recover gold and silver profitably from the same mine site.

With modern technologies and treatment processes, Barrick expects to produce at Pueblo Viejo 1,000,000 ounces of gold per annum. The mine also has reserves of 88 million ounces of silver, 358 million pounds of copper, and 2.6 billion pounds of zinc.

Barrick Gold's Pueblo Viejo Mine in the Dominican Republic (DR) is the largest single investment ever made in DR. The capital budget for Hatch's scope of work alone is \$643 million out of a total project budget of \$3.0 billion.

Pueblo Viejo is one of Barrick's most significant investments and is the DR's richest gold deposit. The chosen process is pressure oxidation of sulphide minerals, thus making the precious metals amenable to cyanidation..

More than 6,000 people are working to bring the mine into production.

Barrick studied the ore body and processing facilities and concluded new mine processing facilities and pressure-vessel processing could be better choices. The pressure oxidation choice

meant that the technology to satisfy the design would require four autoclave vessels, in fact, the largest autoclaves in the world.

With over 85 full time staff and 20 years of experience, Hatch's Autoclave Technology Group is unquestionably the world leader in autoclave circuit design, vessel manufacture, transportation and installation. The client called upon Hatch's Autoclave Group to design the process and implement the pressure oxidation technology.

Each of PV's autoclaves weighs 780 tonnes, and is carbon steel, lead-lined and refractory bricked. The autoclaves will treat 24,000 tonnes of ore per day. They were designed in Mississauga, Canada, constructed in Malaysia and shipped from there to the Dominican Republic in a specifically designed transport ship, the largest, ocean-going heavy lift ship ever launched.

One of the highlights of the project was the transportation of the autoclaves from Malaysia, where they were manufactured, to the Dominican Republic in the Caribbean.

The oxygen plant is a standalone facility that can produce 4,000 tonnes per day of 99.5% by volume pure oxygen.

Among the complications at Pueblo Viejo are a hurricane season that reigns from March to November and lightning strikes. There are evacuation plans for the mine site and to date they have been executed three times.

Hatch is managing the project capital for the following facilities:

- Four oxidation circuits (the autoclaves) treating 24 000 tpd ore
- Two 2000 tpd cryogenic O₂ separation plants
- All related area utilities: steam, air, Acid Rock Drainage water, demineralized water, sea water and cooling water.

The autoclaves transportation logistics were challenging. They were shipped from KNM's Gebeng facility approximately 10 km to the Port of Kuantan in Malaysia. At the port, the autoclaves were loaded onto the Beluga Bremen, a P2 class ship owned by Beluga Charters of Germany. The transportation of the autoclaves marked Beluga Bremen's maiden voyage. The ship can lift up to 1400 tonnes, and is the largest cargo vessel of its class. Two autoclaves were shipped at a time. It took six hours to load the autoclaves into the hold. It was a four-week journey across the Pacific Ocean and through the Panama Canal to the Port of Samana in the north-eastern part of the DR. The autoclaves were off-loaded onto self

propelled mobile trailers (SPMT) and transferred to a 22-line Goldhofer heavy haul trailer for their 120-kilometer, 18-day cross-country trek to the Pueblo Viejo mine site.

Hatch's Autoclave Technology Group also designed the shipping saddles. Advanced finite element analysis (FEA) techniques were used to design the temporary shipping saddles. The Engineers had to account for road inclinations, both for slope and incline, and impact loading safety factors. Consideration also had to be given to protect the autoclave from distortion while supported and transported on the temporary saddles.

Each assembled SPMT consisted of 22 rows of axles with 12 tires per row and a 400-tonne capacity turntable to allow the trailer to rotate under each end of the autoclaves.

Mine History

The Pueblo Viejo mine was operated from 1979 to 1999 by state-owned mining company, Rosario Resources. Gold and silver were recovered from several oxide deposits that produced more than 5 million ounces of gold and 25.2 million ounces of silver until 1991. Gold mining and processing operations at Pueblo Viejo ceased in June, 1999 as the free gold ran out.

As a result, the mining activities left environmental problems that needed to be dealt with. Before building could begin, the land had to be cleared and restored. A massive clean-up effort was required. Eventually 130 000 cubic meters of soil were removed to rid the ground of contaminants.

There were several abandoned process facilities and infrastructure, including two old tailing impoundments, two main open pits, and several

smaller pits. Stockpiles were scattered around the larger pits. Some infrastructure is still in operation, including the water supply system, power station, housing, recreational facilities and two acid-drainage treatment plants.

The old existing transitional ore treatment facilities have been demolished and the new plant gold processing facilities, including the pressure oxidation and oxygen plants were developed.

Project Description

The Pueblo Viejo gold and silver mine is located in central Dominican Republic, near the town of Cotui (KA-TOO-EE), 100 km northwest of the capital city of Santo Domingo at an elevation of 260 meters above sea level. Rio Haina is the nearest all-service port for Pueblo Viejo. It is located 13 km southwest of Santo Domingo.



The Hatch EPCM (Engineering, Procurement & Construction Management) team's scope was responsible for two areas of the plant, the pressure oxidation facility, and the oxygen plant. The oxygen plant is a standalone facility capable of producing 4000 tonnes per day of 99.5% by volume pure oxygen. The oxygen will be used in the oxidation process (autoclaving) for facilitating gold extraction. The autoclave circuit includes all related equipment including slurry pre-heating, pressure letdown, and the off-gas cleaning equipment.

Hatch's autoclave group is made up of individuals from several disciplines, including:

- Metallurgists/Process Engineers
- Mechanical Engineers
- Piping Engineers
- Project Engineers
- Designers

The EPCM project team developed the procedures for project execution, established the project management system for controlling scope, project costs and schedule, and produced monthly project management reports.

Since the previous mine extracted the surface ore, the ore being processed today is refractory and needs special treatment. The process consists of crushing, grinding, pressure oxidation and CIL cyanidation. The gold will be mined by conventional open pit methods. The two pits are Moore and Monte Negro.

The Pueblo Viejo process plant is expected to produce 1,000,000 ounces of gold annually, and has added reserves of 2.6 billion pounds of zinc, 358 million pounds of copper, and 88 million ounces of silver. Hatch is playing a significant role in the development of the project by providing the process design, detailed engineering,

procurement, and project and construction management for the world's largest capacity refractory gold oxidation plant, including custom autoclave and refractory design, a 4 000 tpd oxygen plant, and their related process controls and technologies.

The detailed engineering and procurement for Phase 1 (autoclaves) has been completed and construction of Phase 2 (oxidation plant) is under way.

The keys to Barrick's success are the capabilities of four of the world's largest gold-processing autoclaves. The Barrick mine is only the fifth goldmine in the world to apply autoclaves as a pressure-oxidation solution.

Complexities of the Project

Among the challenges were the planning and preparation of earthworks, roads, demolition of derelict buildings and infrastructure, and repair of some pre-existing facilities.

Space constraints at the site meant the team had to create the most compact process facility layout possible while maintaining access for safe construction, operation and maintenance activities.

The pressure oxidation facility is located on a fixed bench within the site plot plan. The area for the facility had to contain the "foot print" of the plant and allow areas within the plot assigned to "stage" or prepare for the construction work. Areas to set-up equipment such as cranes for lifting equipment and erecting steel had to be allowed for. The sequence of building erection had to be controlled. For example, by not constructing the Assay building until after the autoclaves were installed allowed direct access for the autoclave transporter to enter the pressure oxidation building. The "constructability" and "sequencing" of the construction activities for the



The world's largest autoclaves

plant had to be carefully phased in an efficient and timely manner to suit equipment delivery and site access.

Natural Disasters

Due to Dominican Republic's geography, hurricanes and heavy tropical storms are frequent and demand everyone take cover when they occur. Unfortunately, the region lies within the Caribbean hurricane belt. Hurricane season for the Dominican Republic is from March to November and can be deadly and destructive. Heavy rain and strong winds are typical for these types of storms. The site was evacuated on three occasions during construction for potential hurricane landing forecasts. All events lasted two to three days.

Hatch's Hurricane Evacuation plan successfully evacuated all Hatch site personnel within 48-hours of landfall on three occasions during construction. All structures and services are designed to withstand Class IV hurricanes and seismic zone 3 events.

Transporting the Autoclave: Beluga Bremen

Transporting four 780-tonne autoclaves is no small task. It demands thorough planning and heavy-duty equipment. A logistics program was developed by Hatch's Autoclave Technology Group for the delivery of four autoclaves fabricated in Kuantan, Malaysia to the port through to installation and eventually onto the concrete support piers at the Pueblo Viejo site. The transportation process involved the use of SPMT transporters, significant bridging equipment and the services of the Beluga Bremen "P" Series super heavy lift vessel.

The delivery terms for the autoclaves was FOB Port of Kuantan, Malaysia which required the fabricator to deliver the autoclaves across the ship's rail.

The Beluga Bremen was the first of a new class ("P Series") of heavy lift ship carrying two primary cranes and rigging to lift a total of 1400 tonnes (see Pueblo Viejo: Pressure Oxidation Plant in Appendix A). The Bremen made two



The Beluga Bremen, largest transport ship in its class

sailings, each carrying two autoclaves. The first trip was its maiden voyage which included a second stop at Shanghai to pick up the Oxygen Plant Cold Boxes, also destined for the Pueblo Viejo mine site. The ship successfully crossed the Pacific, passed through the Panama Canal to the Caribbean Sea and eventually to the Port of Samana, Dominican Republic.

At Samana, the ship was met by an assembly of two SPMT's. These trailers consist of custom configurable units that are joined together in a multitude of configurations to satisfy ground pressure limits, manoeuvrability constraints and, when supplemented with auxiliary trucks to add pulling, pushing and braking capacity, they are able to cover large distances over significant grades.

Two added features of the SPMT is its ability to operate and steer independently and negotiate corners that would appear to be beyond reasonable expectation and to utilize their hydraulic systems to raise and lower their cargo deck.

The routes from the fabricator to the port in Malaysia and from the port to the mine site in the Dominican Republic had to be thoroughly surveyed for modifications to infrastructure including bridges, road work, traffic signs and over-head obstructions.

The route itself underwent a four-month program of infrastructure modifications consisting of the raising of countless electrical cables, many of which were illegal to begin with, removal and eventual replacement of road and business signage, widening of pinch points and significant temporary renovation of a town square to permit the transit of the autoclaves. Some bridges were repaired others had steel decking temporarily placed. This decking was then dismantled and "leap-frogged" ahead of the vessel as it travelled along the route.

Twenty-seven bridges, all of which required supplemental engineering, were reinforced with the use of portable ramps, mats or bypassed via a temporary bridge installation. It took seven prime movers to provide supplemental pulling, pushing and braking power over the route.

Twenty-two temporary bridging ramps, ranging in size from 9 meters to 36 meters, all certified for the load plan had to be placed, crossed and moved ahead to bridges further along the route.

The convoy took 18 days to travel the 120 kilometre route from the port to the mine site. Once the autoclave reached the site it was transferred to an SPMT with independent wheel steering for precise control. The autoclave was manoeuvred into the autoclave building between the foundations where jacks lifted the autoclave from the trailer. The autoclave saddles were precisely surveyed during fabrication of the vessels in Malaysia and the anchor bolts in the piers were precisely surveyed on site. This was to ensure an exact fit and no surprises with 780 tonnes supported on the jacks during the transfer from the trailer to the autoclave foundations.

Once located between the piers each autoclave was jacked up, and positioned onto a horizontal slide system. Once on the slide the autoclaves were moved sideways, positioned and lowered onto the previously installed anchor bolts that had been grouted into the autoclave piers. The end result was each autoclave slipped into position like a tight-fitting glove.

Innovative Design

The autoclave is a pressure vessel used for performing chemical oxidation at elevated pressures and temperatures. The process oxidizes the sulphide minerals such as pyrite with high-purity oxygen at 230°C and a pressure of 40 bar (g) to liberate submicron-sized gold. The reactions occur in the four massive pressure vessels called autoclaves, protected by a lead membrane and an acid-resistant brick lining. Each vessel has a capacity of more than 630 cubic meters and



Twenty-seven bridges need special design to bear the weight of the autoclaves

a gross operating weight of 2,300 tonnes. Gas dispersion is done by seven agitators per vessel. Each vessel processes approximately 6,000 tonnes of ore per day and extracts 200,000 to 250,000 ounces of gold per year.

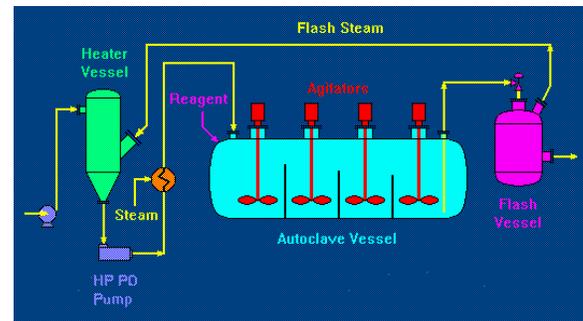
From the design criteria, Hatch determined the vessel size and developed the design over the course of 9 months.

The Pueblo Viejo autoclave statistics are:

- Length: 37.6 meters (123 feet)
- Diameter: 5.6 meters (18.5 feet) inside of steel shell
- Wall Thickness: 100 mm (4 inches)
- Process Volume: 568 cubic meters
- Shipping weight is 780 metric tonnes including 60 metric tonnes of lead membrane
- Lined with 330 mm (13 inches) of refractory brick to protect the lead membrane
- Agitated by seven agitators in five compartments:
 - 4 - 350 HP agitators are in the first two compartments for oxygen gas dispersion
 - 3 – 200 HP agitators in the last three compartments for solids suspension.

The basic circuit consists of a feed system to supply ground ore as a slurry to the autoclave. Each autoclave is divided into a series of compartments by titanium walls of decreasing height to the discharge end. In each compartment there is a series of agitators to mix, disperse oxygen and facilitate the oxidation reactions. Included in the overall circuit is a series of pressure let-down, heat-recovery, and vent-gas

scrubbing equipment. The oxidation of pyrite is highly exothermic and will use direct injection of mine water for cooling.



The basic process design oxidizes sulphides with pure oxygen at 230°C

Once the autoclaves are in place, they were lined with refractory brick. The brick is used to insulate the vessel wall to maintain the inside shell temperature below the maximum design temperature of the lead lining. The lead lining or membrane is homogeneously bonded to the carbon steel shell. The membrane is a corrosion barrier to protect the carbon steel from being destroyed from the corrosive acid generated by the oxidation process within the autoclave.

Quality Surveillance and Fabrication Planning

KNM process systems began forming steel in September 2008. The first autoclave was completed in May 2010 and the fourth autoclave in July 2010.

To give the reader a perspective of the size of one of these autoclaves, 3 large yellow school buses would fit bumper to bumper inside the autoclave, and 123 of these buses would be the equivalent shipping weight of one lead lined

autoclave. Due to the extraordinary size of these vessels they needed to be constructed in modules and then brought together for final fit-up. This was no trivial task. A special fabrication sequence was developed, and equipment, construction, personnel, manufacturing processes, inspections and hold points had to be choreographed and managed so the correct sections were completed to accommodate the proper sequence in the shop for final assembly.

As the Client's representative, Hatch's Autoclave Group oversaw each step of the fabrication process. Autoclave Group engineers and designers along with our welding and materials specialists began a 16-month rotation, 7-day-a-week residency in Kuantan, to plan, monitor and direct the fabrication program.

ATG personnel were assigned to provide continuous coverage of the fabrication and



Local workers line the autoclaves with refractory bricks



Quality procedures dominate the development of Pueblo Viejo

inspection activities. ATG personnel worked with the fabricator and assisted with planning manpower, fabrication sequencing and scheduling to ensure that the autoclaves were fabricated and delivered on schedule. The ATG personnel also conducted quality surveillance of the welding, lead lining, and inspection activities. Due to the immense size of the autoclaves the fabricator had misjudged the welding rotators used during fabrication. ATG Engineers provided design assistance, and new 500 tonne rotators were fabricated in order to complete the fabrication sequence and stay on schedule.

Part of the fabrication process required third-party surveillance. Hatch contacted two well-known inspection and verification companies to monitor the fabrication of the autoclave in Malaysia and to ensure quality and strict observance to the design and procedures. The candidates were interviewed by a team of Hatch engineers to select the most suitable candidate. One was hired and provided 60 hours per week on-site resident inspection services for the duration of the fabrication.

Environmental Impact

Autoclave Environmental Role

Hatch is one of the world's foremost engineering, procurement and construction management firms. For more than 55 years Hatch has been protecting the environment while designing processes for recovering and treating metals and minerals for ore bodies around the world.

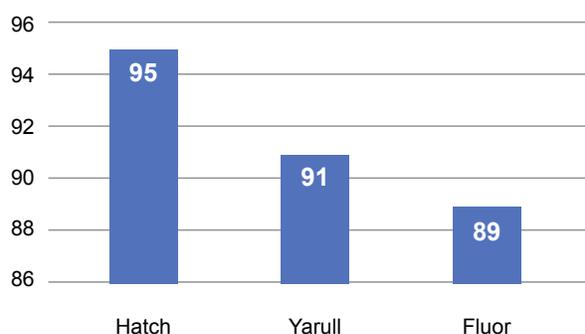
Hatch's development of technology incorporates designs that guarantee a neutral impact on the environment. The autoclaves were specifically selected by Barrick Gold for that purpose.

All sulphides are oxidized, producing sulphuric acid as a by-product which is subsequently neutralised with limestone and lime as part of the gold recovery process. Hatch included a heat recovery circuit that, combined with the nature of the exothermic reactions within the autoclaves, ensures the Client's energy needs are minimal.

Highest Environmental Performance

Barrick Gold awarded Hatch Construction the highest scores for environmental compliance in 2011. Even with that extra care the project remained on track within both schedule and budget. Hatch had the highest average score (95 points) compared with the other principal contractors.

Environmental Performance 2011



Recycling and Recovery

ATG designed the autoclaves so that 90% of the exothermic heat from the autoclave reactions is recovered and recycled to heat slurry feed, lime boil, and the CCD circuit. As the slurry exits the autoclave, the slurry has to return to atmospheric pressure. During the release of pressure, flash steam is captured. The recovered steam is directed to the slurry and lime boil pre-heaters. The pre-heaters are a counter-current design, meaning the steam enters the lower portion of the heater, and flows upward, while the slurry enters the top of the heater and flows downward. By re-using the steam captured from the flash vessel, we eliminate the need for adding steam from the boilers. By recycling the recovered steam, there are also major energy savings. This results in a lower cost of operation and eliminates combustion emissions from the boilers. Without

this circuit, the steam would be vented to atmosphere and the heat energy would be lost.

To assist Barrick in its \$375 million environmental remediation program, Hatch designed a process that reuses acidic mine water (from the pits) for process cooling. The effluent released from the plant is less acidic than the natural groundwater within the watershed.

Soil Erosion

Soil and erosion management programs were carefully designed and took into consideration the local climate factors. Re-vegetation was implemented to limit the effects of erosion, which can cloud waterways. In addition, acid soil stabilization coconut mats were placed along the slopes of recently-constructed access road.

Conservation

Twenty protected plant species have been designated on the site, and they were identified before construction began. Protected species are marked for relocation and transplantation. More than 200 large palm trees were moved as part of an environmental site plan that included species recovery and habitat protection.

In the meantime, 500 000 plants have been relocated and the transplant success rate was a very high 80%. A local nursery produced more than 170 000 plants as part of the site re-vegetation and reforestation efforts.

During the study phase, the Dominican National Historic Museum assisted in the uncovering and relocation of buildings dating back to the early 1500s, when Spanish explorers came to the area. Everything uncovered will be relocated off-site and provided to a museum for preservation and display.

Social and Economic Impacts

The Pueblo Viejo project achieved 3,500,000 work hours with no lost time injuries. The milestone coincides with the team leadership's shared project goal of "no harm, no incidents." "This is a significant accomplishment" says Kevin Fraser, project manager. "The Hatch team has been committed to building a safety culture at the Pueblo Viejo project."

When the mine begins production, the municipalities in the area will receive five percent of total revenues. In 2006, laws were enacted in the Dominican Republic to enable municipalities to hold referendums to decide on local properties. A five-year development plan was developed for the local communities by the residents of Cotui, Maimon, and Fantino. Every resident was invited to vote yes or no to the Pueblo Viejo plan and it was adopted by the majority.

Hatch's portion of the construction contract work has delivered \$44.2 million to the local economy in the form of local contracting of civil/structural works, construction consumables, and support services, food, lodging and security.

Community

Barrick has provided housing as part of relocation packages accepted by those people living adjacent to Pueblo Viejo. The new village will include:

- a church
- a community building
- a polytechnic school
- paved roads, streetlights, a fire hydrant network, and
- water and sewage systems.

The project team is working with the Dominican Ministry of Education, the Canadian Embassy and regional NGOs on programs to raise academic standards at primary and secondary schools and to improve adult literacy. Barrick's plan is to sponsor a significant reforestation project in the area, and further improve the quality of water in the streams.

Barrick also has a longer-term plan to build a dual-fuel power plant to meet the future energy needs of communities in the area.

Health

Health services and facilities are a critical need. Barrick and local agencies designed a program to improve the health status of local communities. In 2009 and 2010, Barrick funded a health prevention educational program that reached more than 22 000 people, including 200 mainly young people who were trained to work with the local municipalities of Cotui, Fantino and Maimon.

The team visited households with the goal of educating residents on hygiene and family and environmental health. Since the completion of the second phase of the program, there have been no reported cases of cholera or a dengue fever, diseases that have plagued the region for decades.

Safety

The project enjoys one of the best safety records in the construction industry, with no loss time injuries after 3.5 million man-hours.

The milestone coincides with the team leadership's shared project goal of "zero harm, zero incidents".

"This is a significant accomplishment", says Kevin Fraser, project manager. "The Hatch team has been committed to building a safety culture



More than 4,000 Dominicans worked on the project

at the Pueblo Viejo project since construction mobilization early on 2009. They arrived with the passion to teach our core values and a commitment to build our safety program on these foundations.”

Throughout the project the Hatch team has been focused on reinforcing the HSEC policy on a daily basis, establishing new goals and targets in the short and long term, investing in knowledge, training and most importantly, maintaining positive interaction between Hatch staff and the local Dominican workforce.

Hatch has roughly 100 staff in the country, and site manpower on site averages 1200 craft workers and support staff.

Quality of Life

Barrick is also contributing to local communities' quality of life by under taking infrastructure improvements in Cotui and Maimon. The type of infrastructures are:

- Community Centre
- School
- Medical Center
- Church

Main street upgrades in Maimon are under way to serve the considerable truck freight that goes through the town. PV has tied into the main grid for site power. The Dominican government will have a new power plant built in San Francisco de

Macoris. It was determined that sufficient capacity is available from the main grid to provide the 150 MW base power required for the PV site. The original plan included the refurbishment of a floating power plant located to the west of Puerto de Haina. PVDC continues to work with local stakeholders to augment the existing power supply to the grid.

Local workers and local companies were hired for the construction project – approximately 4000 Dominicans were hired onto the construction site. Some are general labourers but many were trained as heavy-equipment operators, fire fighters and members of emergency response teams.

Hatch's mechanical, piping, electrical and instrumentation contracts were awarded and executed by regional contractors with the capability to execute the work and with proven track records in similar facilities. The autoclave structural/mechanical/piping package was awarded to a Peruvian heavy industrial mechanical contractor. The Oxygen Plant was awarded to a Mexican contractor with a proven track record in liquid natural gas and oxygen plant installations.

Craft skills training programs were implemented at the start of the project, and job fairs were held country wide. The focus was on training personnel from the surrounding communities in mining and support work, heavy-equipment

operation, and electrical, mechanical and piping craft skills. Hatch and their contractors contributed to this program by hiring personnel from the pool.

The mine is expected to provide 1500 permanent jobs when in production.

Meeting & Exceeding Client Needs

Of the eight projects that Barrick currently has in its investment portfolio, Hatch's work on Pueblo Viejo has met its schedule and budget. While the project forecast is currently tracking at 3% above baseline (2009) estimate, with no contingency, the 3% has been covered by scope changes approved since the control estimate was issued.

As Pueblo Viejo approaches commissioning and start up, Barrick Gold can point to several successful milestones of the project:

- On budget
- On schedule
- Excellent safety record
- Advanced process technology, and
- Full production expected by the end of 2012.